Alberta

MUNICIPAL AFFAIRS

Innovative Housing Grants Program

STRUCTURAL TESTING OF THE NASCOR I PRESERVED WOOD FOUNDATION WALL SYSTEM

November 1987

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The views and conclusions expressed and the recommendations made in this report are entirely those of the authors and should not be construed as expressing the opinions of Alberta Municipal Affairs.

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FOREWORD

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EXECUTIVE SUMMARY

Introduction

Cano Structures Inc. has been producing the NASCOR I preserved wood foundation (PWF) wall system for four years in Alberta and, to date, about 100 units have been constructed. Although the NASCOR I PWF wall system differs slightly from conventional PWF wall systems, its design was based on Canadian Standards Association (CSA) standard CAN3-S406 "Construction of Preserved Wood Foundations". However, compliance of the system with CSA standard CAN3-S406 had not been tested nor had it been evaluated or accepted by Canada Mortgage and Housing Corporation (CMHC). This situation made some builders and homeowners hesitant about using it. Cano Structures Inc. therefore sought assistance under the Innovative Housing Grants Program to conduct structural testing against the appropriate CSA Standard and evaluation by CMHC to obtain formal acceptance of their basement system.

Testing Program

Warnock Hersey Professional Services Ltd. were retained to conduct the testing. The testing program consisted of subjecting four wall panels to a combined vertical load and a lateral load representing backfill pressure. The panels measured 2440 x 2440 (8'x8') and were 200mm (7 7/8") thick. Panels were constructed with 400mm and 600mm (12" and 24") stud spacing. The panels were mounted in a steel test frame to restrain the test panels' lateral movement top and bottom and a uniformly distributed vertical load was applied. Backfill conditions were simulated by filling the test frame's side box with water.

Test Results

Test results were used to develop empirical formulae and allowable backfill height tables for varying vertical loads and stud spacing.

Test results show that the NASCOR I wood basement system complies with CSA CAN3-S406. The results were submitted to CMHC, and CMHC has subsequently accepted the NASCOR I preserved wood foundation wall system (see: "CMHC Evaluation Report No. 11608").

1.0 INTRODUCTION

The NASCOR I foundation wall system is a preserved wood foundation system manufactured by Cano Structures Inc.. Since its introduction into the building market, it has met with enthusiastic response. Many homeowners and builders alike have been impressed by its energy efficiency and structural integrity.

The NASCOR I foundation wall system was designed on the basis of Canadian Standards Association standard CAN3-S406, "Construction of Preserved Wood Foundations." This standard establishes structural limitations on preserved wood foundations (PWF's) on the basis of calculations derived from the properties of the wood studs and also on recommendations made in the Canadian Wood Council's Datafile WB-4, "Preserved Wood Foundations".

Prior to this project, the system had never been tested to determine its compliance with the CSA standard, nor had it been evaluated and accepted by CMHC. Because of this, and because the NASCOR I preserved wood foundation wall system is slightly different from conventional PWF wall systems, some builders and homeowners were hesitant to incorporate it into their buildings. Therefore Cano Structures decided to undertake actual structural testing of the NASCOR I PWF wall and seek CMHC acceptance of the system.

Cano Structures was subsequently given a grant from Alberta Municipal Affairs under the Innovative Housing Grants Program and carried out the appropriate

structural tests. The tests were performed by Warnock Hersey Professional Services Ltd. of Coquitlam, B.C..

This report describes the results of the work and provides related background information. The material has been organized as follows: Section 2 describes the components of the NASCOR I PWF system, Section 3 identifies building code requirements and test objectives. Section 4 outlines test procedures. Sections 5, 6 and 7 discuss test results and product acceptance.

2.0 GENERAL DESCRIPTION OF NASCOR I PWF WALL SYSTEM

Figure 2.0 illustrates a view of a typical NASCOR I foundation wall. The wall consists of 38 x 140mm (2x6) studs, 19 x 89mm (1x4) interior nailer strip, polystyrene infill panels, polystyrene splines, plywood sheathing, a bottom plate, and two top plates. Any wood member that is 200mm (8") or more above finished grade is not required to be preservative treated. All other wood is preservative treated in accordance with CSA Standard 080.15. The wall sits on either a treated wood footing plate over gravel or a concrete footing. The cap plate, footing plate or concrete footing, and plywood sheathing are generally supplied by the customer.

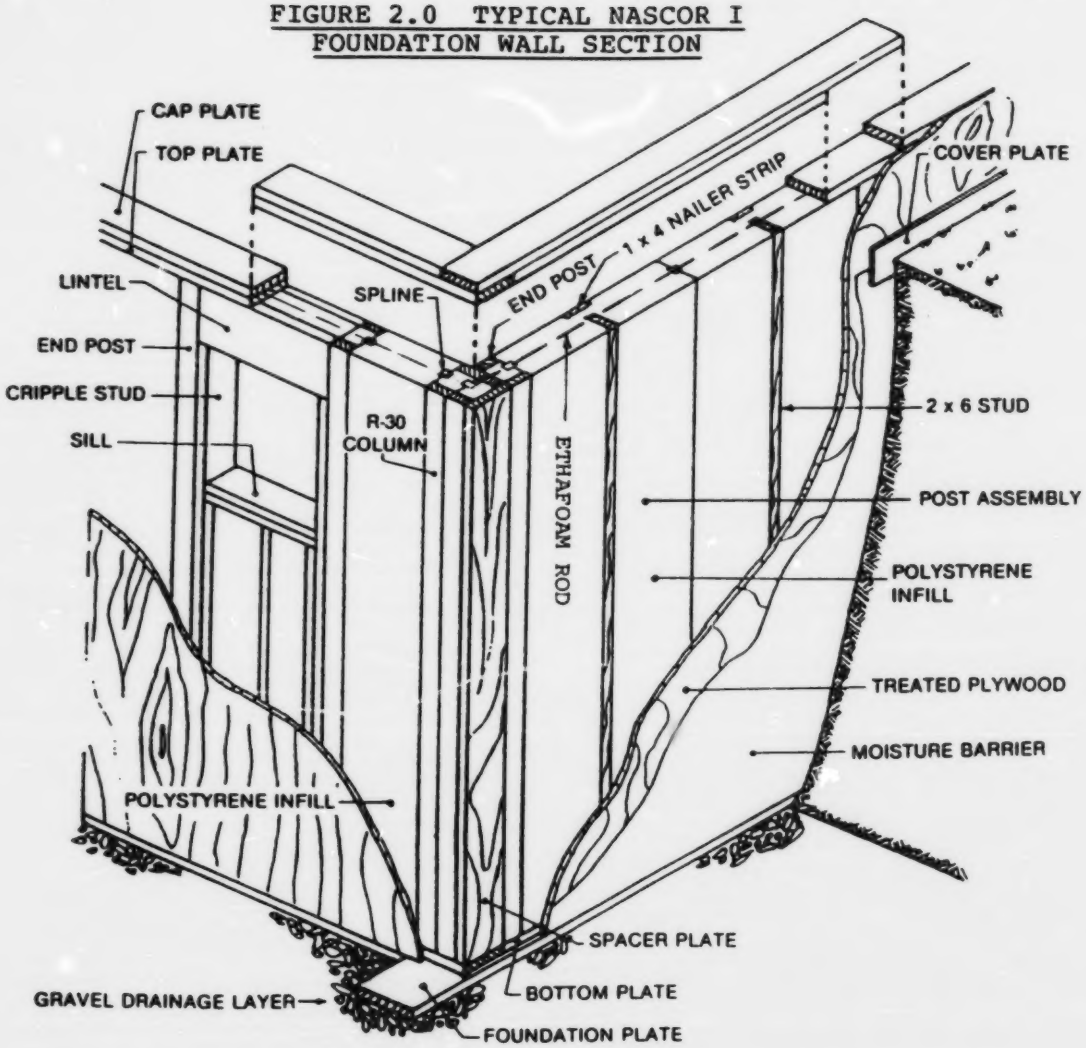
2.1 Component Details

The following subsections provide descriptions of each major component of the NASCOR I preserved wood foundation wall system.

2.1.1 Infill Panel

The NASCOR I PWF wall infill panel is a 184mm (7 1/4") thick polystyrene panel. Each end of the panel has 19 x 38mm (3/4" x 1 1/2") keyways which are intended to interlock with the keyways of adjoining panels by use of splines (see Section 2.1.9 for spline description). The exterior side of the infill panel is profiled to allow a 38 x 140mm (2x6) to be inset. The interior side of the panel is profiled to allow a 19 x 89mm (1x4) to be inset. Both wood members are

FIGURE 2.0 TYPICAL NASCOR I
FOUNDATION WALL SECTION



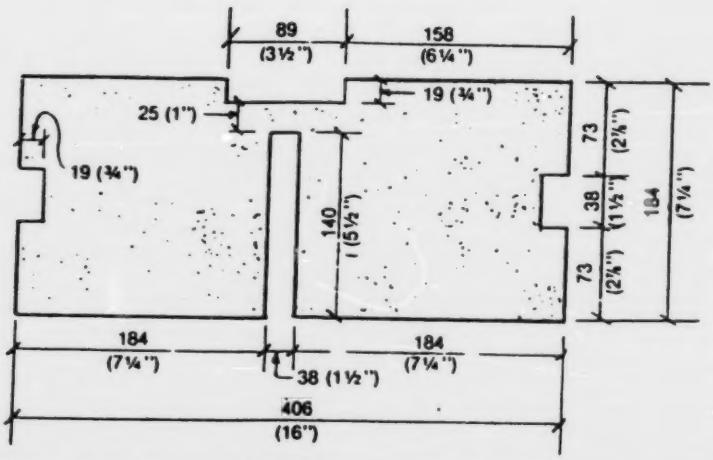


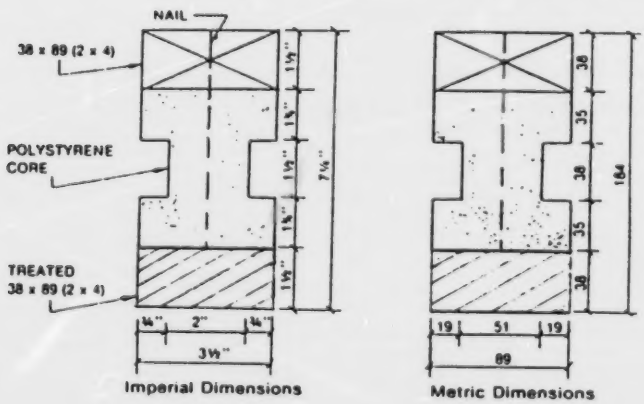
FIGURE 2.1.1 - NASCOR I PWF WALL INFILL PANEL

adhered to the infill panel and the nailer strip is attached through the polystyrene into the stud by means of four nails, staples, or wood screws per length of nailer. Figure 2.1.1 shows a typical infill panel for studs at 400mm (16")o.c.. Panels are also manufactured for 300mm (12") and 600mm (24") stud spacing. The infill panel can be manufactured to accommodate 38 x 184mm (2x8) studs although this is not very common. When the infill panel has been wooded (wood members attached), it is called a post assembly.

2.1.2 Columns

The NASCOR I PWF column, illustrated in Figure 2.1.2, is constructed of two 38 x 89mm (2x4) wood studs adhered to a polystyrene core. The whole section is nailed together with three nails per length of column. One of the 38 x 89mm (2x4) studs is preservative treated and this side of the column is placed on the exterior side of the foundation wall. The polystyrene core is profiled on both sides to facilitate air tight connections of columns with infill panels or post assemblies by use of splines. Columns are used at corner locations (see Figure 2.0).

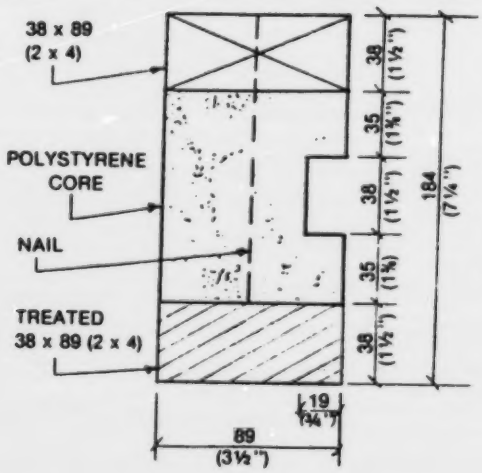
FIGURE 2.1.2 NASCOR I PWF COLUMN



2.1.3 End Posts

The NASCOR I PWF end post, as illustrated in Figure 2.1.3, is constructed of two 38 x 89mm (2x4) wood studs adhered to a polystyrene core. The whole section is nailed together with three nails per length of post. One of the 38 x 89mm (2x4) studs is preservative treated and this side of the end post is placed on the exterior side of the foundation wall. Unlike the columns, the polystyrene core is profiled on one side only. End posts are used at corners and at rough openings for windows and doors.

FIGURE 2.1.3 - NASCOR I PWF END POST



2.1.4 Lintels and Rough Openings

The lintel, illustrated in Figure 2.1.4(a), is constructed of two 38 x 235mm (2x10) wood members with a polystyrene infill spacer between them. The wood is not preservative treated. The polystyrene is adhered to both wood members and they are connected by two rows of nails spaced at 450mm (18")o.c. The framing

that supports the lintel can be done as shown in Figure 2.1.4(b). For lintel spans over 1500mm (5') a 38 x 184mm (2x8) treated stud must be added between the end post and the lintel cripple. For lintel spans over 1800mm (6') two additional 38 x 184mm (2x8) treated wood studs must be added between the end post and the lintel cripple.

FIGURE 2.1.4(a) TYPICAL FOUNDATION WALL LINTEL

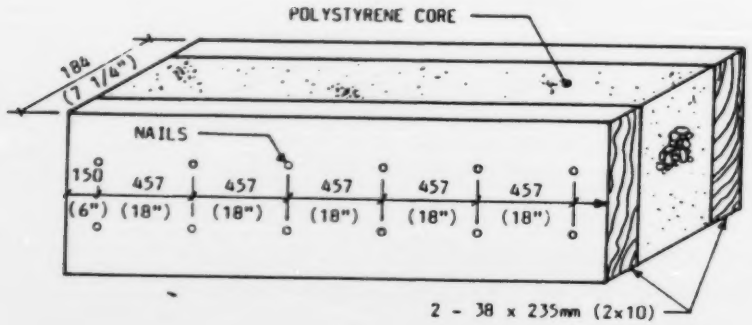
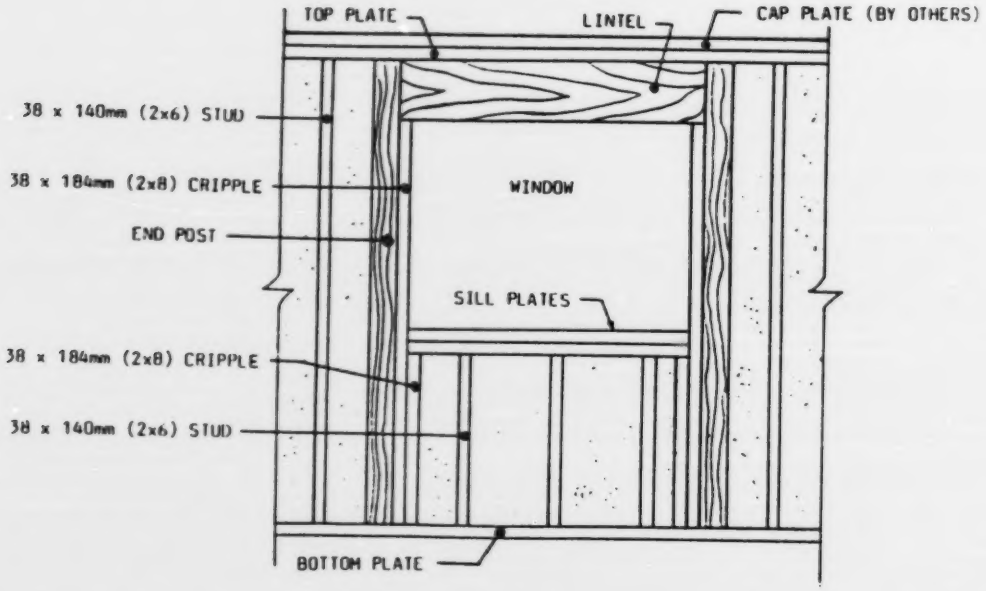


FIGURE 2.1.4(b) EXTERIOR ELEVATION - ROUGH OPENING



2.1.5 Spacer Plate

The spacer plate is a 38 x 148mm (2x8) preservative treated wood member (see Figure 2.0). It is attached to the end post at every corner and its purpose is to tie the corner together as well as to bring the edge of the column beyond the interior surface of the abutting wall. This placement ensures a backing for installation of interior and exterior finishes.

2.1.6 Top and Bottom Plates

The standard prefabricated NASCOR I foundation wall system consists of one upper plate and one lower plate. The top plate consists of an untreated 38 x 184mm (2x8) wood member. Between the top plate and the wall components (that is, the infill panels and columns) a continuous ethafoam backer rod is installed to ensure a good air seal. An untreated 38 x 184mm (2x8) cap plate (supplied by others) is placed over the top plate to join the wall panels together when the foundation is erected.

The bottom plate is installed during the prefabrication of the wall panels and consists of a preservative treated 38 x 184mm (2x8) wood member. As with the top plate, a continuous ethafoam backer rod is installed between the bottom plate and the wall components to ensure a good air seal.

The foundation wall panels sit on either a preservative treated, wooden foundation plate or a concrete footing.

2.1.7 Plywood Sheathing

The plywood sheathing used on the NASCOR I foundation wall is usually 15.9mm (5/8") thick, preservative-treated Douglas Fir. Depending on loading conditions, 12.9mm (1/2") or 19mm (3/4") thick plywood is also used. The plywood is nailed to the 38 x 140mm (2x6) studs with the face grain perpendicular to the studs. All joints between the plywood sheets below grade are sealed by bedding the plywood edges in a sealant (butyl caulking). Plywood sheathing generally supplied by the client.

2.1.8 Moisture Barrier

The exterior plywood sheathing of the NASCOR I foundation wall system is usually covered by a 0.150mm (6 mil) thick polyethylene sheet as an added protection against moisture penetration. The polyethylene is strip bonded to the plywood and the joints are lapped a minimum of 600mm (2'). The top edge is sealed to the plywood and covered with a treated plywood strip approximately 75mm (3") above the finished exterior grade. The bottom edge of the polyethylene extends down to the bottom of the wood foundation plate and terminates at the top of the gravel bed.

Alternatively, two coats of bitumastic damp-proofing may be used in place of the polyethylene. Quite often, both methods are used together. The moisture barrier is the responsibility of the client.

2.1.9 Spline

The spline is a solid section of polystyrene insulation measuring 38 x 38mm (1 1/2" x 1 1/2") whose purpose is to act as an airlock and connecting mechanism between the various components of the NASCOR I PWF wall. It is a friction-fit installation that interlocks the keyways of the post assemblies, columns, and end posts (see Figure 2.0).

2.1.10 Studs

The standard NASCOR I PWF wall system uses 38 x 140mm (2x6) wood studs as the loadbearing components. The studs are pressure treated in accordance with CSA 080.15. There are a number of available species of PWF studs which can be used but the most common used by Cano Structures is Lodgepole Pine, No. 1 or No. 2 grade in a standard length of 2363mm (93").

3.0 BUILDING CODE REQUIREMENTS AND TESTING OBJECTIVES

All PWF's must comply with the CSA Standards CAN3-S406, "Construction of Preserved Wood Foundations". Other applicable codes and standards with which the NASCOR I preserved wood foundation wall system must comply are listed below:

a) National Building Code of Canada or the corresponding provincial codes;

b) CSA CAN-086-M, "Code for Engineering Design in Wood";

c) CSA B 111, "Wire Nails, Spikes and Staples";

d) NLGA, 1980, "Standard Grading Rules for Canadian Lumber";

e) CSA 080.15, "Preservative Treatment of Wood for Building Foundations Systems, Basements and Crawl Spaces by Pressure Process";

f) CGSB 19-GP-14M, "Sealing Compound, One Component, Butyl - Polyisobutylene Polymer Base, Solvent Curing";

g) CGSB 37-GP series, "Bituminous Damproofing";

h) CGSB 51-GP-20M, "Thermal Insulation, Expanded Polystyrene"; and

i) CSA 0121-M, "Douglas Fir Plywood".

All PWFs, including the NASCOR I PWF wall system are structurally designed in conformance with Part 4 of the National Building Code of Canada (or Part 4 of provincial building codes). In addition, PWFs are required to be designed and inspected during construction by a qualified professional engineer in most provinces.

The CSA Standard CAN3-S406 outlines maximum backfill heights for preserved wood foundation walls in Table 5a of the standard (for concrete slab floors or crawlspace foundations) and Table 8a of the standard (for suspended wood floors). The tables are reproduced on pages 13 and 14 respectively.

The NASCOR I preserved wood foundation wall system uses preservative-treated lodgepole pine studs at a standard length of 2362mm (93"). Therefore, the NASCOR I PWF wall would be classed as "PWF III, No.1 and No.2" according to CSA CAN3-S406.

The objective of the testing program was to develop loading tables and product reviews that could be submitted in support of applications for regulatory acceptances. In general, the tests were to demonstrate that the NASCOR I PWF system could meet the requirements outlined in CAN3-S406.

Table 5a

Maximum Backfill Heights (m) for Various Sizes (mm) of Wood Foundation Studs for Exterior Walls with Concrete Slab Floors or for Crawl Space Foundations

Maximum Building Width (Parallel to Joists)	Lumber		One Storey Above Foundation				Two Storeys Above Foundation			
	Species Class*	Grade	38 x 89 @ 300	38 x 140 @ 400	38 x 140 @ 300	38 x 184 @ 400	38 x 89 @ 300	38 x 140 @ 400	38 x 140 @ 300	38 x 184 @ 400
6 m	PWF I	Sel. Str.	1.4	1.9	2.3	2.4	1.4	1.9	2.3	2.4
		No.1,No.2	1.1	1.5	1.7	1.9	1.1	1.4	1.7	1.8
	PWF II	Sel. Str.	1.3	1.7	2.0	2.1	1.3	1.7	2.0	2.1
		No.1,No.2	1.2	1.6	1.8	2.0	1.1	1.5	1.8	1.9
	PWF III	Sel. Str.	1.3	1.6	1.9	2.0	1.3	1.6	1.9	2.0
		No.1,No.2	1.2	1.6	1.8	2.0	1.1	1.5	1.8	1.9
	PWF IV	Sel. Str.	1.1	1.5	1.7	1.9	1.0	1.4	1.7	1.8
		No.1,No.2	0.9	1.2	1.4	1.5	0.8	1.2	1.4	1.5
	PWF V	Sel. Str.	1.1	1.5	1.8	1.9	1.0	1.5	1.7	1.9
		No.1,No.2	0.9	1.3	1.4	1.6	0.8	1.2	1.4	1.5
8 m	PWF I	Sel. Str.	1.4	1.9	2.3	2.4	1.3	1.9	2.2	2.4
		No.1,No.2	1.1	1.4	1.7	1.8	1.0	1.4	1.6	1.8
	PWF II	Sel. Str.	1.3	1.7	2.0	2.1	1.2	1.7	2.0	2.1
		No.1,No.2	1.1	1.5	1.8	1.9	1.1	1.4	1.7	1.9
	PWF III	Sel. Str.	1.3	1.6	1.9	2.0	1.2	1.6	1.9	2.0
		No.1,No.2	1.1	1.5	1.8	1.9	1.0	1.4	1.7	1.8
	PWF IV	Sel. Str.	1.0	1.4	1.7	1.8	0.9	1.4	1.6	1.8
		No.1,No.2	0.8	1.2	1.4	1.5	0.7	1.1	1.3	1.4
	PWF V	Sel. Str.	1.0	1.5	1.7	1.9	0.9	1.4	1.7	1.8
		No.1,No.2	0.8	1.2	1.4	1.5	0.7	1.2	1.4	1.5
10 m	PWF I	Sel. Str.	1.3	1.9	2.2	2.4	1.2	1.8	2.2	2.4
		No.1,No.2	1.0	1.4	1.7	1.8	0.9	1.3	1.6	1.7
	PWF II	Sel. Str.	1.3	1.7	2.0	2.1	1.2	1.7	2.0	2.1
		No.1,No.2	1.1	1.5	1.8	1.9	1.0	1.4	1.7	1.8
	PWF III	Sel. Str.	1.3	1.6	1.9	2.0	1.1	1.6	1.9	2.0
		No.1,No.2	1.0	1.4	1.7	1.9	0.9	1.3	1.6	1.8
	PWF IV	Sel. Str.	0.9	1.4	1.7	1.8	0.8	1.3	1.6	1.7
		No.1,No.2	0.7	1.1	1.3	1.4	0.6	1.0	1.2	1.3
	PWF V	Sel. Str.	0.9	1.4	1.7	1.9	0.8	1.4	1.6	1.8
		No.1,No.2	0.7	1.2	1.4	1.5	0.6	1.1	1.3	1.4

**Species class is shown in Table 1.*

Notes:

(1) Backfill height is defined in Clause 2.

(2) Design assumptions of Clause 1.1.3 apply.

(3) Buildings are assumed to have conventional siding consisting of wood, metal, plastics, stucco, or other non-masonry cladding.

(4) This Table also applies when masonry veneer is carried on a knee wall conforming to Clause 3.12.2.

TABLE 3.1 - TABLE 5a OF CAN3-S406-M83

Table 8a

Maximum Backfill Heights (m) for Various Sizes (mm) of Wood Foundation Studs for Exterior Walls with Suspended Wood Floor

Maximum Building Width (Parallel to Joists)	Lumber		One Storey Above Foundation				Two Storeys Above Foundation			
	Species Class*	Grade	38 x 89 @ 300	38 x 140 @ 400	38 x 140 @ 300	38 x 184 @ 400	38 x 89 @ 300	38 x 140 @ 400	38 x 140 @ 300	38 x 184 @ 400
6 m	PWF I	Sel. Str.	2.1	2.5	2.9	2.9	2.1	2.5	2.9	2.9
		No.1,No.2	1.7	2.3	2.5	2.6	1.6	2.2	2.4	2.6
	PWF II	Sel. Str.	2.0	2.3	2.6	2.6	2.0	2.3	2.6	2.6
		No.1,No.2	2.0	2.3	2.6	2.6	1.8	2.3	2.5	2.6
	PWF III	Sel. Str.	2.0	2.2	2.5	2.5	2.0	2.2	2.5	2.5
		No.1,No.2	1.9	2.2	2.5	2.5	1.7	2.2	2.5	2.5
	PWF IV	Sel. Str.	1.7	2.1	2.4	2.4	1.5	2.1	2.4	2.4
		No.1,No.2	1.1	1.8	2.2	2.3	0.9	1.7	2.1	2.2
	PWF V	Sel. Str.	1.8	2.3	2.5	2.7	1.6	2.3	2.5	2.6
		No.1,No.2	1.2	2.0	2.2	2.3	1.0	1.9	2.2	2.3
8 m	PWF I	Sel. Str.	2.1	2.5	2.9	2.9	2.1	2.5	2.9	2.9
		No.1,No.2	1.6	2.2	2.4	2.6	1.4	2.2	2.4	2.5
	PWF II	Sel. Str.	2.0	2.3	2.6	2.6	2.0	2.3	2.6	2.6
		No.1,No.2	1.8	2.3	2.5	2.6	1.6	2.2	2.5	2.6
	PWF III	Sel. Str.	2.0	2.2	2.5	2.5	2.0	2.2	2.5	2.5
		No.1,No.2	1.7	2.2	2.5	2.5	1.4	2.2	2.4	2.5
	PWF IV	Sel. Str.	1.6	2.1	2.4	2.4	1.3	2.1	2.4	2.4
		No.1,No.2	0.9	1.7	2.1	2.2	0.8	1.5	2.1	2.2
	PWF V	Sel. Str.	1.6	2.3	2.5	2.6	1.4	2.2	2.4	2.6
		No.1,No.2	1.0	1.9	2.2	2.3	0.9	1.7	2.1	2.0
10 m	PWF I	Sel. Str.	2.1	2.5	2.9	2.9	2.1	2.5	2.9	2.9
		No.1,No.2	1.5	2.2	2.4	2.5	1.3	2.1	2.4	2.5
	PWF II	Sel.Str.	2.0	2.3	2.6	2.6	2.0	2.3	2.6	2.6
		No.1,No.2	1.6	2.2	2.5	2.6	1.3	2.2	2.4	2.5
	PWF III	Sel. Str.	2.0	2.2	2.5	2.5	2.0	2.2	2.5	2.5
		No.1,No.2	1.5	2.2	2.5	2.5	1.2	2.1	2.4	2.5
	PWF IV	Sel. Str.	1.4	2.1	2.4	2.4	1.1	2.1	2.3	2.4
		No.1,No.2	0.8	1.5	2.1	2.2	0.6	1.2	2.0	2.1
	PWF V	Sel. Str.	1.4	2.2	2.5	2.6	1.2	2.2	2.4	2.5
		No.1,No.2	0.9	1.8	2.2	2.3	0.7	1.6	2.1	2.2

**Species class is shown in Table 1.*

Notes:

(1) Backfill height is defined in Clause 2.

(2) Design assumptions of Clause 1.1.3 apply.

(3) Buildings are assumed to have conventional siding consisting of wood, metal, plastics, stucco, or other non-masonry cladding.

(4) This Table also applies when masonry veneer is carried on a knee wall conforming to Clause 3.12.2.

TABLE 3.2 - TABLE 8a OF CAN3-S406-M83

4.0 TESTING PROCEDURE

CMHC requires that building components and assemblies which are being submitted for its acceptance be tested by an "approved" laboratory. One such lab is Warnock Hersey Professional Services Ltd., of Coquitlam, B.C. which was engaged to undertake the necessary work. The NASCOR I PWF system was subjected to structural testing to determine allowable backfill heights and to compare these values with those in CSA Standard CAN3-S406 (see Tables 3.1 and 3.2 of this report). Four wall panels were tested. The wall panels measured 2440mm x 2440mm (8'x8') and were 200mm (7 7/8") thick (which included the 15.5mm (5/8") thick plywood sheathing on the exterior face). Three of the panels consisted of 38 x 140mm (2x6) treated studs spaced at 600mm (24") on center and the fourth panel had studs spaced at 300mm (12") on center.

The testing apparatus consisted of a steel test frame into which the test panels were mounted. A uniformly distributed vertical loading was applied through a steel I-beam controlled by hydraulic pressure and monitored by a pressure gauge. To represent the lateral loading from backfill pressures, Warnock Hersey constructed a 2440x 2440mm (8'x8') by 900mm (3') wide box and placed it against the test panel.

The first test was performed by filling the side box with wet Fraser River sand to simulate backfill conditions. The other three tests were conducted by filling the box with water, which seemed to provide more realistic results and also corresponded more

closely to the loading assumptions made in CAN3-S406.

The test panels were mounted in the steel test framework and were restrained from lateral movement at the top and bottom by attaching 38 x 184mm (2x8) wood joists at 300mm (12") on center to the top and bottom of the wall panel. This was intended to simulate actual floor construction in an average house. With the joists attached, the wall panel had a clear span of 2134mm (84"). A vertical uniformly distributed load of 29 kN/m (2000plf) was applied to the top of the wall panel. At each 600mm (2') increment the deflection at mid-height of the wall panel was measured at two points near the center and the average deflection was recorded. The axial load was then reduced and the whole procedure repeated. It should be noted that the axial load was applied to the top of the test panels at an eccentricity of one-third the wall thickness towards the interior surface of the wall, that is, 32mm (1.25") from the center line of the wall towards the interior of the wall.

5.0 DISCUSSION OF TEST RESULTS

Test results were used to confirm the structural capacity of the NASCOR I PWF system and to establish allowable backfill height tables for varying load conditions.

The allowable backfill heights in Warnock Hersey's two tables in Appendix #1 are based on a foundation wall height of 2440mm (8') for basement floors consisting of a concrete slab-on-grade, crawl space, or wood sleeper floor and a wall height of 3048mm (10') for suspended wood basement floors. A suspended wood floor is generally located 600mm (2') above the ground (or bottom of the foundation wall).

An inspection of Warnock Hersey's allowable backfill height tables found in Appendix #1 shows that with increasing vertical loads (dead plus live loads) on the NASCOR I PWF wall system the allowable backfill heights also increase. This is the opposite situation to that indicated in the allowable backfill height tables of the CSA Standard (reproduced in Table 3.1 and 3.2) where increasing vertical loads cause a decrease in the allowable backfill heights. The major reason for this apparent non-conformity is probably due to the testing procedure used by Warnock Hersey. In Warnock Hersey's test of the wall panels the vertical load was applied at an eccentricity of one-third the wall thickness. The centerline of the applied vertical load was located 32mm (1.25") from the centerline of the wall panel toward the interior face of the wall panel. Warnock Hersey chose to test

the wall panels under an eccentric vertical load as it seems to simulate more accurately the action of floor loads in actual field conditions.

Loading the test panels with an eccentric vertical load on the interior side of the wall panel creates a prestressing effect on the wood studs which tends to bend them toward the exterior. The application of the lateral load on the studs in the form of backfill has to then overcome the slight outward bending before any inward deflection of the studs can occur. Therefore, the larger the vertical load, the more pronounced the outward bending of the studs and this creates the requirement for a larger lateral load (a higher backfill height) to cause an inward deflection of the studs. It is important to note, however, that under normal vertical loads which are encountered in actual practice (such as those assumed in the CSA Standard), the prestressing effect is negligible and the values of allowable backfill heights in Warnock Hersey's tables are essentially equivalent to those in CSA CAN3-S406.

Another important consideration in the testing of the NASCOR I PWF wall panels was the deletion of the 38 x 89mm (2x4) backing behind the horizontal joints of the exterior plywood sheathing between the studs. This is a requirement for conventional PWF walls in CSA CAN3-S406. Warnock Hersey concluded the omission of this backing in the NASCOR I PWF wall caused no deleterious effects as the NASCOR expanded polystyrene provides sufficient backing.

6.0 PRODUCT ACCEPTANCE BY REGULATORY AUTHORITIES

6.1 Product Acceptance by CMHC

CMHC product acceptance results in the issuance of a material evaluation report. Such a report can be used to boost customer confidence in the product and, in the case of the NASCOR I PWF wall system, allows the system to be used in CMHC - insured housing.

After the necessary information and test data were submitted to CMHC, "CMHC Materials Evaluation Report number 11609" was issued. The report completely describes the NASCOR I PWF system and its usage and limitations. It also includes maximum allowable backfill height tables; confirms compliances with the National Building Code of Canada; describes the on-site installation procedures; and describes how the system is to be identified.

6.2 Product Acceptance by Alberta Building Standards

The Building Standards Division of Alberta Labour reviews and evaluates building products in much the same manner as CMHC. Upon its acceptance of a building product, an Alberta Standata product listing is issued which is very similar in format to that issued by CMHC.

Cano Structures Inc. has not applied for an Alberta Standata product listing on the NASCOR I PWF wall system. The principal reasons for this are as follows:

(i) The purpose behind obtaining an Alberta Standata is so building officials readily accept the product without requiring the company to certify it by a professional engineer every time it is intended to be used. However, the Alberta Building Code requires that all PWF wall systems must be designed and inspected by a qualified professional engineer. Therefore, even if Cano Structures Inc. obtained an Alberta Standata, it still has to involve a professional engineer for every proposed use.

(ii) The NASCOR I PWF wall system is already recognized by building officials throughout most of Alberta (over 100 units have been constructed to date).

(iii) The company feels the CMHC evaluation report will serve its needs adequately where concerns of building code conformance or consumer confidence arise.

6.3 Product Acceptance by ICBO in the United States

When Cano Structures Inc. decided to enter the U.S.A. market with the NASCOR product line, it intended to include the NASCOR I PWF wall system in the application package to building code authorities. The International Conference of Building Officials (ICBO) was the regulatory authority chosen out of the three major regulatory authorities in the USA. With ICBO product acceptance in place, the other two authorities would accept a similar application almost automatically.

However, before making a formal application to ICBO for the NASCOR I PWF wall system, Cano Structures Inc. performed a market research program and discovered there is very little demand for basements in the USA especially in the West where the company intended to concentrate its marketing efforts. Therefore ICBO product acceptance was not pursued since the wall system will not be marketed in the USA in the foreseeable future.

7.0 CONCLUSION

Structural testing was performed on a number of NASCOR I preserved wood foundation wall panels to establish the structural capacity in terms of allowable backfill heights for the wall system.

Allowable backfill height tables were established by Warnock Hersey Professional Services Ltd. for the NASCOR I PWF wall system. The test results confirmed that the NASCOR wall constructed with 38 x 140mm (2x6) treated wood studs can achieve allowable backfill heights equivalent to those provided in CSA Standard CAN3-S406 for conventionally built preserved-wood foundations. CMHC's acceptance of the test results have led to its issuance of "CMHC Evaluation Report No. 11608".

The expanded polystyrene insulation (EPS) was found to provide ample lateral support to the wood studs within the plane of the NASCOR I PWF wall so the insulation can be considered to add a measure of strength to the wall system. Also, the EPS acts as backing for the exterior plywood sheathing so the 38 x 89mm (2x4) wood blocking behind the plywood joints between the studs, as required in conventionally constructed PWFs, can be safely eliminated in the NASCOR I PWF wall.

The structural testing of the NASCOR I PWF wall system confirmed all of Cano Structures Inc.'s expectations regarding the structural performance of the wall. This should increase customer acceptance of the NASCOR I PWF system.

APPENDIX A - REVISED BACKFILL HEIGHT TABLES BY WARNOCK HERSEY

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B.C. V3K 4X9 Tel: (604) 520-3321 Envoy WPM 8076

May 27, 1987

Cano Structures Inc.
7803P 35th Street, S.E.,
Calgary, Alberta
T2C 1V3

Attention: Dave Burnes, P. Eng.

Dear Dave;

Re: Backfill Height Tables for Preserved Wood Foundation Walls

I have recalculated the tables for backfill heights using Span/300 as deflection criteria as required by CMHC.

Upon reviewing the test results it seems more appropriate to use an EI Value of 16.0×10^6 $lb.in^2$ instead of 14.7×10^6 $lb.in^2$ used in the original calculations. The EI Value of 16.0×10^6 $lb.in^2$ is the average value obtained for backfill heights of 5 feet to 7 feet.

New tables are enclosed herewith.

WARNOCK HERSEY PROFESSIONAL SERVICES LTD

Yours truly,

F. Mawani

F. Mawani, P. Eng.,
Manager,
Field Inspections & Physical Testing

FM/lsw 87.05.27

LOAD TABLES FOR NASCOR
P.W. FOUNDATION WALL

1. Maximum Backfill Heights for PWF's with concrete slab, crawl space, or wood sleeper floors.

Lumber = S.P.F. Grade #2 or Better

Stud Size = 2" x 6" (1.5" x 5.5" actual size) (38 mm x 140 mm)

Plywood = 5/8" thick (16mm)

VERTICAL LOAD

Stud Spacing	0 0	100 1.5	200 2.9	300 4.4	400 5.8	500 7.3	1000 14.6	1500 21.9	2000 29.2	2500 36.5	3000 43.8	PLF KN/M
12"	66	66.5	67	67.5	68	68.5	70.8	73	75	77	79	ins.
300 mm	1.68	1.69	1.70	1.71	1.72	1.73	1.80	1.85	1.90	1.95	2.00	mtrs.
16"	59.5	60	60.5	61	61.5	62	64.5	67	69.5	71.5	-	ins.
400 mm	1.51	1.52	1.54	1.55	1.56	1.57	1.64	1.70	1.76	1.82	-	mtrs.
20"	55	55.5	56	57	57.5	58	60.5	63	65.5	-	-	ins.
500 mm	1.40	1.41	1.42	1.45	1.46	1.47	1.54	1.60	1.66	-	-	mtrs.
24"	51.5	52	53	53.5	54.5	55	58	60.5	-	-	-	ins.
600mm	1.31	1.32	1.34	1.36	1.38	1.40	1.47	1.54	-	-	-	mtrs.

LOAD TABLES FOR NASCOR
P.W. FOUNDATION WALL

2. Maximum backfill heights for PWF with suspended Wood Floors

Lumber S.P.F. Grade #2 or better

Stud size = 2" x 6" (1.5" x 5.5" actual size) (38 mm x 140 mm)

Plywood = 5/8" thick (16 mm)

VERTICAL LOAD

Stud Spacing	0 0	100 1.5	200 2.9	300 4.4	400 5.8	500 7.3	1000 14.6	1500 21.9	2000 29.2	2500 36.5	3000 43.8	PLF KN/M
12" 300 mm	90 2.28	90.5 2.30	91 2.31	91.5 2.32	92 2.34	92.5 2.35	94.8 2.41	97 2.46	99 2.51	101 2.56	103 2.61	ins. mtrs.
16" 400 mm	83.5 2.12	84 2.13	84.5 2.15	85 2.16	85.5 2.17	86 2.18	88.5 2.25	91 2.31	93.5 2.37	95.5 2.42	- -	ins. mtrs.
20" 500 mm	79 2.00	79.5 2.02	80 2.03	81 2.06	81.5 2.07	82 2.08	84.5 2.15	87 2.21	89.5 2.27	- -	- -	ins. mtrs.
24" 600 mm	75.5 1.92	76 1.93	77 1.95	77.5 1.97	78.5 1.99	79 2.01	82 2.08	84.5 2.15	- -	- -	- -	ins. mtrs.

APPENDIX B - NASCOR I PWF WALL SYSTEM TEST REPORT

BY WARNOCK HERSEY

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B.C. V3K 4X9 Tel: (604) 520-3321 Envoy WPM 8076

REPORT OF

COMBINED AXIAL AND TRANSVERSE LOAD TEST

ON

CANO STRUCTURES INC. NASCOR PRESERVED WOOD FOUNDATION WALL SYSTEM

FOR

CANO STRUCTURES INC.
7803P 35TH STREET, S.E.,
CALGARY, ALBERTA
T2C 1V3

REPORT NO. 2/86

DATE: SEPTEMBER 29, 1986

BY: _____

F. MAWANI, P. Eng.,
Manager,
Field Inspections

Warnock Hersey Professional Services Ltd.

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INTRODUCTION:

As requested, we have carried out combined axial and transverse load tests on Cano Structures Inc. Nascor Preserved Wood Foundation (PWF) Wall System. The purpose of these tests was to determine the structural properties and behaviour of segments of a wall panel developed by Cano Structures Inc.

DESCRIPTION OF THE NASCOR PWF WALL SYSTEM:

The Nascor preserved wood foundation wall test panels were 184 mm (7 1/4") thick, by 2440 mm x 2440 mm (8'0" x 8'0"). The panels were constructed using 38 mm x 140 mm (2"x6") preservative treated wood studs spaced at 600 mm (24") on centre and at 300 mm (12") on centre. On the exterior side preservative treated 16 mm (5/8") Douglas Fir plywood was used as sheathing. The space between the studs was filled with expanded polystyrene of the same thickness as the wall. 19 mm x 89 mm (1"x4") untreated wood nailer strips were placed parallel to the plane of the wall and on the interior side in line with the studs. Double 38 mm x 184 mm (2"x8") untreated wood top plates and a treated wood bottom plate were screwed to the studs.

Nascor R30 foundation columns were used to cap the ends of the wall panels.

All untreated lumber was of S.P.F #2 and better grade. All treated lumber was S.P.F #1 Grade.

The studs and the nailer strips were both set into the profiles on opposite sides of the EPS insulation infill panels and were adhered to them. The nailer strips were also attached to the studs by means of four wood screws per length of nailer strip.

The Nascor R30 foundation wall column consists of a 108 mm (4 1/4") thick by 89 mm (3 1/2") wide polystyrene core adhered on each of its 38 mm (3 1/2") wide faces to two 38 mm x 89 mm (2"x4") wood studs (i.e. 2 wood members and a polystrene core per column). The stud on the exterior side was preservative treated. The studs in the R30 column were placed so as to have the wide face of the stud parallel to the wall panel. The Nascor R30 column measures 184 mm (7 1/4") thick by 89 mm (3 1/2") wide. The EPS infill panels are interlocked with the column cores by use of polystyrene splines to hold the infill panels in place.

TEST PROCEDURE:

COMBINED AXIAL AND TRANSVERSE LOAD TEST

Tests were performed on three like specimens. The test specimens supplied by Cano Structures Inc. were 2440 mm high x 2440 mm wide (8'0" x 8'0") 184 mm (7 1/4") thick.

The test panel was secured in the steel test frame and was restrained from moving laterally by attaching 38 mm x 141 mm (2" x 8") joists at the top and bottom of the wall at 305 mm (12") o.c. This left a clear span of 2134 mm (84") for the wall. The intent was to simulate the actual floor construction of the 1st storey and basement. No sheathing was applied on the interior side of the wall.
A 915 mm (3') deep box, 2440 mm (8') high x full width of the wall was constructed on the exterior side. The purpose was to apply the lateral pressure of backfill on the foundation wall at various heights of backfill and measure the deflection of the wall at mid height. An axial load of 2,000 PLF. was applied to the wall at the start of the test. The deflection at mid height of the wall at full axial load was recorded. The axial load was applied at the inner third of the top surface area. The test on the first panel was carried out using Fraser River sand as backfill material.

An additional test panel with studs at 300 mm (12") o.c. and a linear axial load of 2,000 PLF. was tested to develop load tables.

The sand was loosely placed into the box by a conveyor belt. At each 610 mm (2') height of backfill the deflection of the mid height of the wall at two centre stud locations was recorded and averaged. The test was continued until a 2438 mm (8') height of backfill was achieved and deflection recorded. At this point it was attempted to fail the wall by applying increasing axial load, however at an axial load of 2700 PLF. Our test frame could not support the load and the test was discontinued.

The second and the third tests and the test on studs at 300 mm (12") o.c. were performed using water to simulate backfill material.

All deflections were measured using dial indicators reading to 0.025 mm (0.001").

Structural formulas were derived to calculate the stiffness factor (EI) of the stud system. EI values were calculated for each reading. Load tables were calculated using combined axial and lateral load formulas for long columns.

TEST RESULTS:

Combined axial and lateral load formulas were used to derive the test results. The axial load was applied at an eccentricity of one third the wall thickness. (i.e. at a distance of 32 mm (1.25") towards the interior from the centre line of the stud.) The EI value of each stud with respective axial load and respective backfill height was calculated and plotted. The minimum EI value obtained for each axial load condition was used to compute the load tables since these seem more appropriate as the lower EI values were obtained for the higher backfill heights.

CONCLUSIONS:

Tests were carried out in our laboratory to determine the load carrying capacities of the PWF Nascor Foundation Wall System.

The vertical load applied at an eccentricity of one third the thickness of stud towards the inside surface of the wall, bent the stud column outwards, thereby giving it bending movement in opposite direction to that given by backfill. Therefore until the design stress values of the lumber are exceeded, increasing values of vertical load would allow greater backfill heights.

Test results indicate that the Nascor Preserved Wood Foundation Walls can withstand larger backfill heights than those listed in Canadian Wood Council datafile WB-4 for 38 mm x 140 mm (2" x 6") studs for PWF Species Class III No.1 and No.2.

The expanded polystyrene insulation seems to be providing sufficient lateral support and as such we do not see any need to provide lateral blocking between the studs. However, the plywood joints should be adequately caulked or waterproofed.

The Nascor Foundation Wall seems to perform better than a conventional 38 mm x 140 mm (2"x 6") PWF Wall under the load conditions as stipulated in our testing.

ASSUMPTIONS FOR CALCULATING LOAD TABLES

1. Foundation Wall Heights:

   a) 96 ins. (2400 mm) for concrete slab floor foundation.

   b) 120 ins. (3008 mm) for suspended wood floor foundation.

2. Lateral Load from soil pressure equivalent to fluid pressure of 4.7 Kn/M^2 per metre depth = 30 $lbs./ft.^2$ per ft. depth.

3. Load Duration Factor = 0.90

4. Deflection = $L/180$

5. Load Application:

IMPORTANT

The tables are computed on the basis that the vertical load is applied at an eccentricity of one third the wall thickness towards the interior surface of the wall. (i.e. 1.25" from the centre line of the stud towards the interior of the wall.) Tests carried out under these conditions indicated in all cases that the column bent outwards with the application of the vertical load and inwards with the application of the lateral loads. Hence increasing the vertical load until the allowable lumber stresses were exceeded, gave increasing outward bending and as such it can be seen that with the increasing vertical load, greater backfill heights are achieved. (i.e. vertical loads apply a negative movement whereas the lateral loads apply a positive movement.)

6. It is assumed that a design engineer will specify adequate lateral support at the top and bottom of the walls.

L O A D T A B L E S

LOAD TABLES FOR NASCOR P.W. FOUNDATION WALL

1. Maximum Backfill Heights for PWF's with concrete slab, crawl space, or wood sleeper floors.

Lumber = S.P.F. Grade #2 or Better

Stud Size = 2" x 6" (1.5" x 5.5" actual size) (38 mm x 140 mm)

Plywood = 5/8" thick (16mm)

VERTICAL LOAD

Stud Spacing	0 0	100 1.5	200 2.9	300 4.4	400 5.8	500 7.3	1000 14.6	1500 21.9	2000 29.2	2500 36.5	3000 43.8	PLF KN/M
12" 300 mm	78 1.98	78 1.98	78.5 1.99	78.5 1.99	79 2.01	79 2.01	81 2.06	83 2.11	84 2.13	86 2.18	87 2.21	ins. mtrs.
16" 400 mm	70 1.78	70 1.78	70.5 1.79	70.5 1.79	71 1.80	71.5 1.82	73 1.85	75 1.91	76.5 1.94	78 1.98	- -	ins. mtrs.
20" 500 mm	64 1.63	64 1.63	64.5 1.64	65 1.65	65.5 1.66	65.5 1.66	68 1.73	69.5 1.77	71.5 1.82	- -	- -	ins. mtrs.
24" 600mm	60 1.52	60 1.52	60.5 1.54	61 1.55	61.5 1.56	62 1.57	63.5 1.61	65.5 1.66	- -	- -	- -	ins. mtrs.

LOAD TABLES FOR NASCOR
P.W. FOUNDATION WALL

2. Maximum backfill heights for PWF with suspended Wood Floors

Lumber S.P.F. Grade #2 or better

Stud size = 2" x 6" (1.5" x 5.5" actual size) (38 mm x 140 mm)

Plywood = 5/8" thick (16 mm)

VERTICAL LOAD

Stud Spacing	0 0	100 1.5	200 2.9	300 4.4	400 5.8	500 7.3	1000 14.6	1500 21.9	2000 29.2	2500 36.5	3000 43.8	PLF KN/M
12"	102	102	102.5	102.5	103	103	105	107	108	110	111	ins.
300 mm	2.59	2.59	2.60	2.60	2.62	2.62	2.67	2.72	2.74	2.79	2.82	mtrs.
16"	94	94	94.5	94.5	95	95.5	97	99	100.5	102	-	ins.
400 mm	2.39	2.39	2.40	2.40	2.41	2.43	2.46	2.51	2.55	2.59	-	mtrs.
20"	88	88	88.5	89	89.5	89.5	92	93.5	95.5	-	-	ins.
500 mm	2.24	2.24	2.25	2.26	2.27	2.27	2.34	2.37	2.43	-	-	mtrs.
24"	84	84	84.5	85	85.5	86	87.5	89.5	-	-	-	ins.
600 mm	2.13	2.13	2.15	2.16	2.17	2.18	2.22	2.27	-	-	-	mtrs.

A P P E N D I X

Warnock Hersey Professional Services Ltd.

FORMULA FOR CALCULATING BACKFILL HEIGHTS

By moment area method and using approximate solution method from James Grassie "Elementary Theory of Structures", P. 351.

Load duration factor (0.9) x EI x (deflection,d.) =

(Moment due to backfill-Moment due to vertical eccentric load] x

$$\frac{2}{3} \times \frac{\text{span (L)}}{2} \times \frac{5 \times \text{span (L)}}{6}$$

From Page 2:

$$0.9 \times EI \times (\text{deflection,d}) = [0.174a^3 - .0043(2a-1)^3 - P(e-d] \times \frac{10}{96} L^2$$

e = eccentricity

for L= 96", stud spacing = 16" o.c., deflection d=l/180=0.533"

and P=100 lbs.;

The equation is:

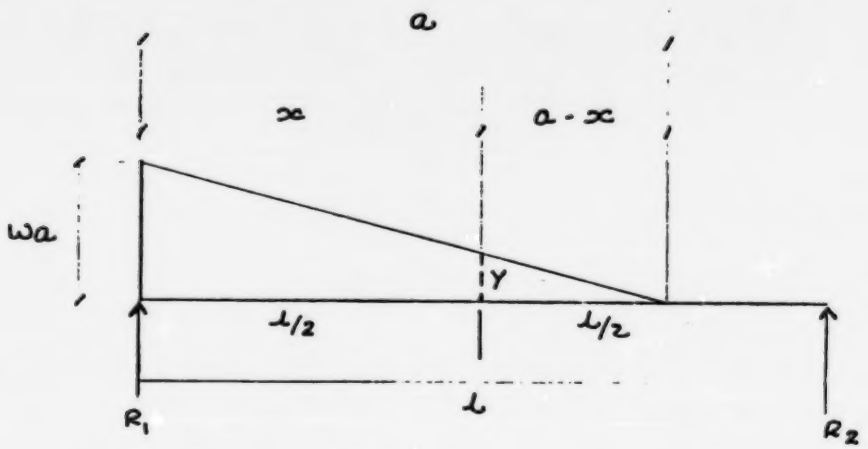
$$0.9 \times EI \times .533 = \frac{16}{12} [.0174a^3 - .0043(2a-96)^3 - 100\ (1.25-.533)]$$

$$\frac{10 \times 96^2}{96}$$

$$\frac{0.9 \times 14.7 \times 10^6 \times .533}{960} = .0231a^3 - .00572(2a-96^3) - 133(1.25-.533)$$

For any backfill condition $\geq$ span/2

Bending moment at mid span =



$$\frac{wa^3}{12^2x6L}(L-X) - \frac{w}{12^2x6}(a-x)^3$$

w=lateral pressure from soil lbs/ft^2 per ft. depth

for x = 1/2 the equation reduces to

$$\frac{wa^3}{12^3} - \frac{w}{12^3x6x8}(2a-L)^3$$

a=backfill height

for w = 30 lbs/ft^2 per ft. depth

$$= \frac{30 \times a^3}{12^3} - \frac{30}{12^2x8x6}(2a-L)^3$$

$$=.0174a^3 - .0043\,(2a-L)^3$$

SAMPLE CALCULATIONS FOR MAXIMUM BACKFILL HEIGHTS

DATA:

a) Wall Height = 96 inches

b) Lateral Pressure (w) from soil = 30 lbs/ft^2 per ft. depth

c) Load duration factor = 0.9

d) Deflection = L/180 = $\frac{96}{180}$ = 0.533"

e) EI of the Stud Column = 14.70 x 10^6 lb. in^2 (determined by tests)

f) Stud Spacing = 16" o.c.

g) Vertical Load on the wall = 100 lbs/lin. ft.

i.e. load per stud column = 133 lbs.

From the above data:

$$\frac{0.9 \times 14.7 \times 10^6 (0.533)}{960} = \frac{0.0231a^3 - 0.00572 (2a - 96^3) -}{133 (1.250 - .533)}$$

a = backfill height

SAMPLE CALCULATIONS: Cont'd

Solving for "a" by Trial and Error

a = 70 inches

Check for Stresses on Lumber

a) Axial Stress: Crushing perpendicular to grain on top plate.

Load = 133 lbs.
Area = 1.5 x 5.5 = 8.25 in^2

$\therefore$ Stress = $\frac{133}{8.25}$ = 16.1 psi

Allowable for S.P.F. = 245 psi $\therefore$ O.K.

Bending Moment at Centre = 133 (1.25 - .533)
Due Axial Load = 95 lb. in.

M at centre due to lateral

Load = 1.33 $\left[\frac{30 \times 70 \times 70^2}{12 \times 144} - \frac{30 \times 70}{12 \times 12 \times 6 \times 70}\left(\frac{96}{2} + 70 - 96^3\right)\right]$

= 1.33 [5955 - 370] lb.in.

= 7428 lb. in.

$\therefore$ Net M at Centre - 7428 - 95 lb. in.

= 7333 lb. in.

$\therefore$ Bending Stress $\frac{7333}{(7.56)}$ = 970 psi

Allowable for S.P.F. #2 = 1987 psi $\therefore$ O.K.

TEST RESULTS

Test No. 1: Studs at 24" o.c. water used as backfill material.

Average Deflection of the wall with an axial load of 2000 lbs/lin.ft. = - 0.159"

Depth of Backfill	Average Deflection of the wall at centre
36"	+ 0.115"
48"	+ 0.253"
72"	+ 0.683"
84"	+ 1.126"
96"	+ 1.480"

Span = 84 ins.

Vertical load applied at 1.25" from the centre line of the wall.

Test No. 2: Studs at 24" o.c. water used as backfill material.

Average Deflection of the wall with an axial load of 2000 lbs/lin.ft. = - 0.149 ins.

Depth of Backfill	Average Deflection of the wall at centre.
24"	+ 0.072"
48"	+ 0.286"
72"	+ 0.663"
78"	+ 0.998"

Span = 48"

Vertical Load applied at 1.25" from the centre line of the wall.

TEST RESULTS: Cont'd

Test No. 3: Studs at 24" o.c. sand used as backfill material.

Average Deflection of the wall with an axial load of 2000 lbs./lin.ft. - Not recorded. Average of the values obtained in Test 1 and 2 used for calculation.

Depth of Backfill	Average Deflection of the wall at centre.
24"	+ 0.042"
48"	+ 0.135"
72"	+ 0.343"
96"	+ 0.594"

Span = 84 ins.

Lateral pressure of loose sand assumed to be 35 lbs/ft^2 per foot depth.

Vertical load applied at 1.25" from the centre line of the wall.

Test No. 4: Studs at 12" o.c. water used as backfill material.

Average Deflection of the wall with an axial load of 2000 lbs/lin.ft. = - 0.137"

Depth of Backfill	Average Deflection of the wall at centre
24"	+ 0.019"
48"	+ 0.183"
72"	+ 0.578"
96"	+ 1.154"

Warnock Hersey Professional Services Ltd.

EI Values Obtained by Test Data

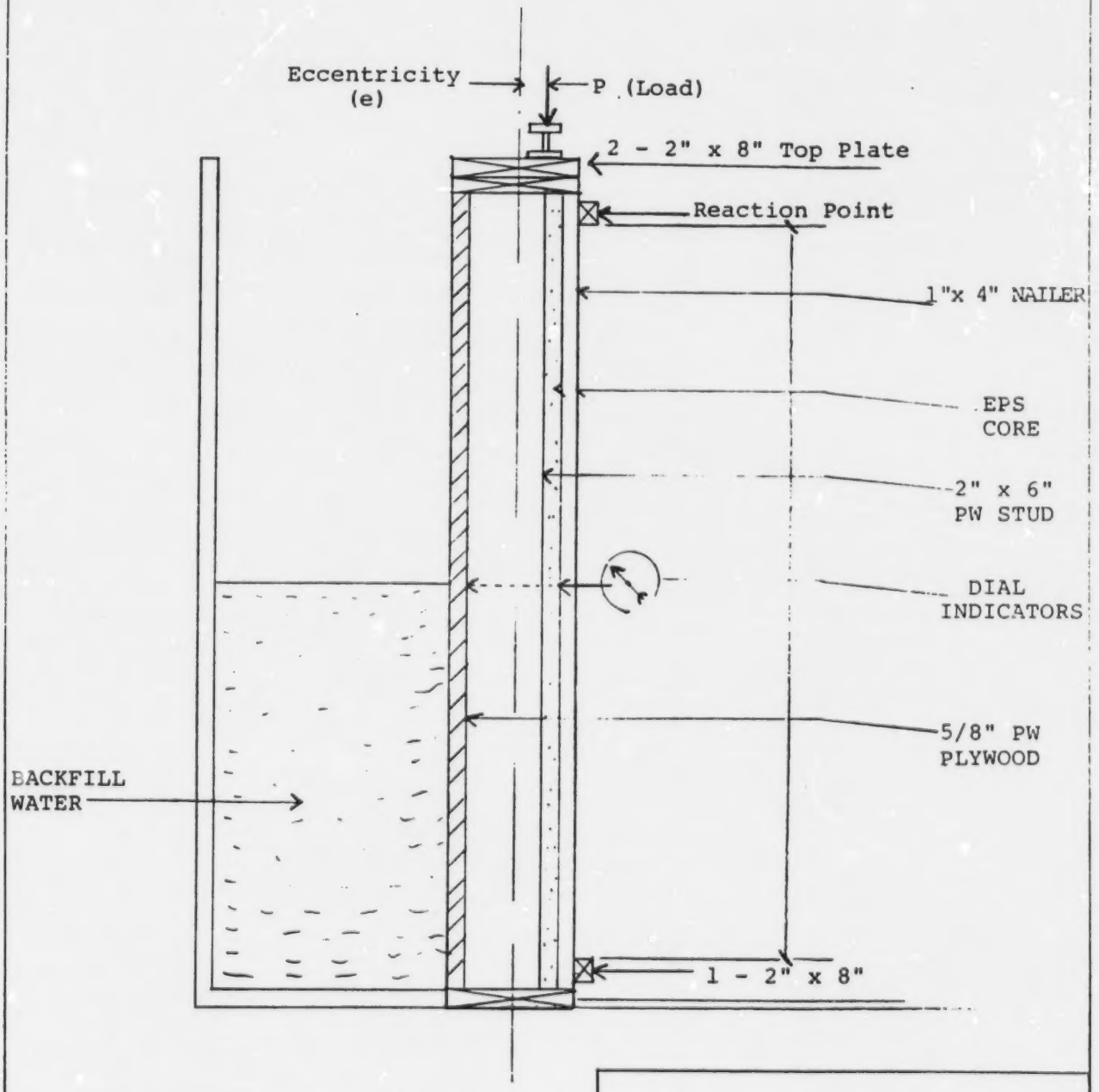
Axial Load = 2000 lbs/lin.ft.

Backfill Condition	EI Values x 10^6 lb.in^2			
	Studs at 24" o.c. i.e. Axial Load = 4000 lbs/stud			Studs at 12" o.c. i.e. Axial Load 2000 lbs/stud
	1	2	3	1
No Backfill	29.8	31.6	-	17.09
2' Backfill	-	46.6	34.2	15.7
3' Backfill	53.9	-	-	-
4' Backfill	5.7 *	4.8 *	94.8 *	4.3 *
6' Backfill	22.2	22.6	24.4	12.9
6'6" Backfill	-	18.6	-	-
7' Backfill	20.1	-	-	-
8' Backfill	18.0	-	27.4	11.3

*Not used for load table calculations

480.D5.PC

FM/lsw

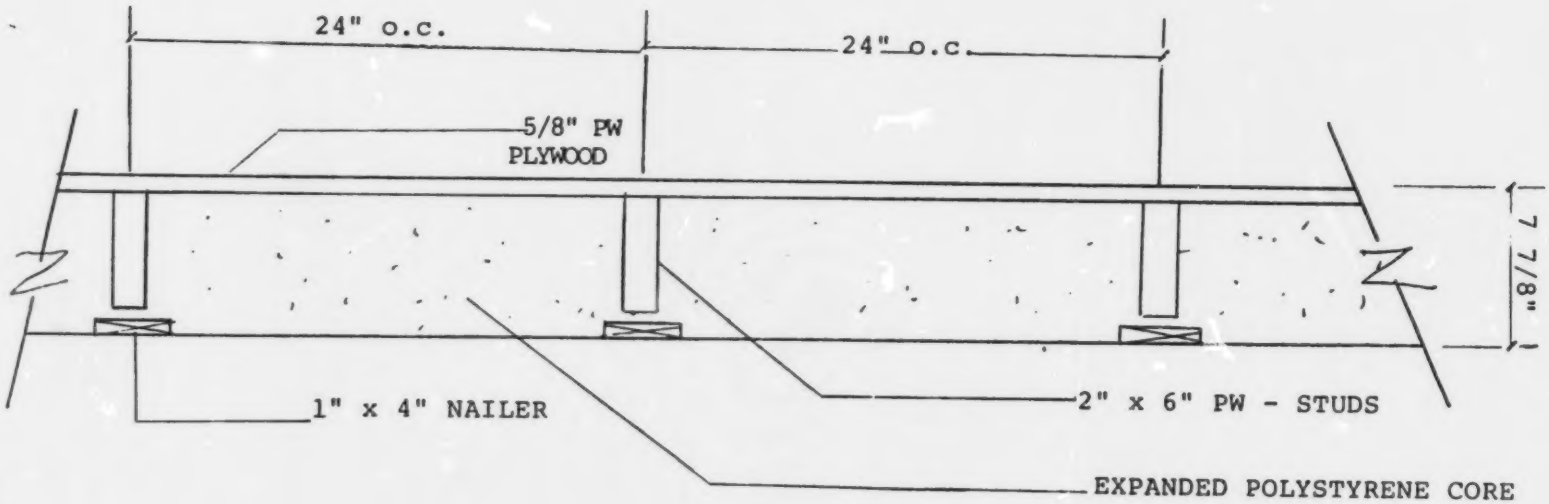


CLIENT CANO STRUCTURES INC.

PROJECT PWF WALL SYSTEM

PARTICULARS COMBINED AXIAL & LATERAL LOAD TEST

Warnock Hersey



CLIENT	CANO STRUCTURES INC.
PROJECT	PRESERVED WOOD FOUNDATION WALL
PARTICULARS	TYPICAL WALL CROSS-SECTION

Warnock Hersey

APPENDIX C - CMHC EVALUATION REPORT #11608 OF THE NASCOR I PWF WALL SYSTEM

Canada Mortgage and Housing Corporation
National Office
Ottawa
K1A 0P7

Société canadienne d'hypothèques et de logement
Bureau National
Ottawa
K1A 0P7

DIVISION 06300

BUILDING MATERIAL EVALUATION REPORT

EVALUATION REPORT NO.: 11608
ISSUE DATE: 87-09-29

NUMBER OF PAGES: 24

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"NASCOR I PRESERVED WOOD FOUNDATION WALL"

1.0 PRODUCT

Preserved wood foundation wall system.

2.0 PROPONENT

Cano Structures Inc., 7803P 35 Street S.E., Calgary, Alberta, T2C 1V3.

3.0 MANUFACTURED AT

(1) Cano Structures Inc., 7803P 35 Street S.E., Calgary, Alberta, T2C 1V3.
(2) Cano Structures Inc., 140 Riviera Drive, Markham, Ontario, L3R 5M1.
(3) Cano Structures Inc., 9747 199A Street, Langley, British Columbia, V3A 4P8.
(4) Interior Thermal Structures Inc., 929 Laval Crescent, Kamloops, British Columbia, V2C 6B9.

4.0 DESCRIPTION

General Description

Figure 4.1 shows a view of a typical NASCOR I foundation wall. The wall consists of 38 x 140 mm studs, 19 x 89 mm interior nailer strip, polystyrene infill panels, polystyrene splines, plywood sheathing, a bottom plate, and two top plates. Any wood member which is 200 mm or more above finished grade is not required to be preservative treated. All other wood is preservative treated in accordance with CSA Standard 080.15. The wall sits on either a treated wood footing plate over gravel or a concrete footing. The cap plate, footing plate or concrete footing, moisture barrier and plywood sheathing are generally supplied by the customer.

4.1 Infill Panel

The foundation wall infill panel is a 184 mm thick polystyrene panel. Each end of the panel has 19 x 38 mm keyways cut out which are intended to interlock with the keyways of adjoining panels by use of splines. The exterior side of the infill panel is profiled to allow a 38 x 140 mm stud to be inset. The interior side of the panel is profiled to allow 19 x 89 mm wood strapping to be inset. Both wood members are adhered to the infill panel. Figure 4.1.1 shows a typical infill panel for studs at 400 mm o/c. Panels are also manufactured for 300 mm and 600 mm stud spacing. Although not very common, the infill panel can be manufactured to accommodate 38 x 184 mm studs. When the infill panel has been framed (wood members attached), it is then referred to as a post assembly.

4.2 Columns

The NASCOR I foundation wall column is constructed of two 38 x 89 mm wood studs adhered to a polystyrene core. The whole section is nailed together with three nails per length of column. Both of the 38 x 89 mm studs are preservative treated. The polystyrene core is profiled on both sides to facilitate air tight connections of columns with infill panels or post assemblies (see Figure 4.1.2). Columns are used at corner locations (see Figure 7.5 (a)).

4.3 End Posts

The NASCOR I foundation wall end post is constructed of two 38 x 89 mm wood studs adhered to a polystyrene core. The whole section is nailed together with three nails per length of post. Both of the 38 x 89 mm studs are preservative treated. The polystyrene core is profiled on one side only (see Figure 4.1.3). End posts are used at corner locations and at rough openings for windows and doors (see Figure 7.5 (a)).

4.4 Lintels and Rough Openings

The lintel is constructed of two 38 x 235 mm wood members with a polystyrene infill spacer between them. The wood is not preservative treated. The polystyrene is adhered to both wood members and they are connected by two rows of nails spaced at 450 mm o/c (see Figure 4.1.4 (a)). The framing which supports the lintel can be done as shown in Figure 4.1.4 (b). For lintel spans over 1500 mm, a 38 x 184 mm treated stud must be added between the end post and the lintel cripple. For lintel spans over 1800 mm two additional 38 x 184 mm treated wood studs must be added between the end post and the lintel cripple.

4.5 Spacer Plate

The spacer plate is a 38 x 184 mm preservative treated wood member (see Figure 7.5 (a)). It is attached to the end post at every corner and its purpose is to tie the corner together as well as to bring the edge of the column beyond the interior surface of the abutting wall. This placement ensures a backing for installation of interior and exterior finishes.

4.6 Top and Bottom Plates

The standard prefabricated NASCOR I foundation wall system consists of one upper plate and one lower plate. The top plate consists of an untreated 38 x 184 mm wood member. Between the top plate and the wall components (i.e. infill panels and columns) a continuous ethafoam backer rod is installed to ensure a good air seal. A cap plate (supplied by others) is placed over the top plate when the foundation wall panels are installed at the site to join the wall panels together (see Figure 4.1). The cap plate is an untreated 38 x 184 mm wood member.

The bottom plate is installed during the prefabrication of the wall panels and consists of a preservative treated 38 x 184 mm wood member. As with the top plate, a continuous ethafoam backer rod is installed between the bottom plate and the wall components to ensure a good air seal.

The foundation wall panels either sit on a preservative treated, wooden foundation plate or a concrete footing. See Section 7.3 for alternate footing details.

4.7 Plywood Sheathing

The plywood sheathing used on the NASCOR I foundation wall is usually 15.9 mm thick preservative treated Douglas Fir. Depending on loading conditions, 12.9 mm or 19 mm thick plywood is also used. The plywood is nailed to the 38 x 140 mm studs with the face grain perpendicular to the studs. All joints between the plywood sheets below grade are sealed by bedding the plywood edges in a sealant (butyl caulking). Plywood sheathing is generally supplied by the customer.

4.8 Moisture Barrier

The exterior plywood sheathing of the NASCOR I foundation wall is usually covered by a 0.15 mm polyethylene sheet as an added protection against moisture penetration. The polyethylene is strip bonded to the plywood and the joints are lapped a minimum of 600 mm. The top edge is sealed to the plywood and covered with a 12.5 mm by 300 mm treated plywood strip approximately 75 mm above the finished grade. The bottom edge of the polyethylene extends down to the bottom of the wood foundation plate and terminates at the top of the gravel bed. The moisture barrier is the responsibility of the customer.

4.9 Wood Studs

The NASCOR I foundation wall system utilizes preservative treated 38 x 140 mm wood studs as the loadbearing components. The studs are 2363 mm long for concrete slab floor basements or 2972 mm for suspended wood floor basements. When loading conditions dictate, 38 x 184 mm preservative treated wood studs may be used.

5.0 USAGE AND LIMITATIONS

The NASCOR I preserved wood foundation wall is permitted for use in construction financed or insured under the National Housing Act subject to the following conditions:

(1) The NASCOR I preserved wood foundation wall system is permitted for use in buildings which are two storeys or less in building height above the foundation and have a building area not exceeding 600 m^2 and where a wall assembly is permitted to be of combustible construction.

(2) The design of the NASCOR I preserved wood foundation wall shall be in accordance with the requirements of CSA Standards CAN3-086-M84, "Engineering Design in Wood (Working Stress Design)", or CAN3-086.1-M84, "Engineering Design in Wood (Limit States Design)".

(3) The construction of the NASCOR I preserved wood foundation wall shall conform to the requirements of CSA Standard CAN3-S406-M83, "Construction of Preserved Wood Foundations".

(4) Except as set forth in Clause (5) all lumber and plywood used in the NASCOR preserved wood foundation panel shall be preservatively treated in accordance with CSA Standard 080.15-M1983, "Preservative Treatment of Wood for Building Foundation Systems, Basements, and Crawl Spaces by Pressure Process".

(5) Lumber need not be treated where it is located more than 200 mm above the adjacent exterior grade.

(6) All lumber and plywood that is required to be treated when incorporated in preserved wood foundation shall be identified as such by a certification mark stamped on the material that confirms that it has been treated in conformance with CSA Standard 0322, "Procedure for Certification of Pressure-Treated Wood Materials for Use in Preserved Wood Foundations".

(7) All staples and nails used below grade for fastening treated lumber and plywood shall be stainless steel conforming to American Iron and Steel Institute (AISI) Type 304 or Type 316.

(8) All nails used above grade shall be hot dipped galvanized conforming to CSA Standard B111-1974, "Wire Nails, Spikes and Staples".

(9) Aluminum, plain steel or electrogalvanized nails shall not be used to fasten treated material.

(10) The structural framing lumber shall be S-P-F #2 or better.

(11) The exterior plywood sheathing shall be a minimum thickness of 12.5 mm.

(12) Treated lumber shall not be cut, notched, or drilled to allow the passage of mechanical or electrical services.

(13) All treated lumber and plywood which must be field-cut to size shall have the cut surface protected with a brushed-on or sprayed-on application of preservative solution recommended by the lumber supplier.

(14) All framing anchors and straps shall be hot-dipped galvanized steel conforming to ASTM A 446, "Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality".

(15) The cap plate should lap the top wall plate by at least 610 mm at every joint.

(16) The size and spacing of the wall studs and thickness of plywood shall be as specified by a licensed NASCOR manufacturer or by a consulting engineer.

(17) The maximum backfill height shall be as specified by a licensed NASCOR manufacturer or by a consulting engineer.

(18) Openings shall be framed with lintels designed to carry the superimposed loads to adjacent studs. Where two or more members are used in the lintels, they shall be fastened together with not less than 82 mm nails in a double row with nails spaced not more than 450 mm apart in each row. Lintels shall be supported by a minimum of one NASCOR I end post and one 38 x 184 mm cripple stud at each end for lintel lengths up to 1500 mm. For lintel lengths longer than 1500 mm, extra 38 x 184 mm cripple studs may be necessary and shall be as specified by a licensed NASCOR manufacturer or a consulting engineer. The cripple studs shall be attached to the NASCOR I end posts with minimum 76 mm stainless steel screws in two rows with screws spaced at 300 mm on center.

(19) The polystyrene insulation shall be protected on the interior surface by one of the finishes described in Section 9.30 of the National Building Code of Canada 1985.

(20) The blocking behind the plywood joints as specified in CSA Standard CAN3-S406 is not necessary in the NASCOR System where the plywood joint is supported by the polystyrene insulation.

(21) All joints between the plywood sheathing panels shall be sealed by a caulking compatible with the preservative treated lumber and plywood.

(22) Electrical wiring may be run in the horizontal electrical keyway provided in the NASCOR foundation wall system. Cuts for receptacle boxes and vertical runs of wiring may be accomplished in the EPS by using a hot knife, router, or equivalent method which minimizes the damage to the insulation without impairing its thermal resistance value.

(23) A vapour barrier conforming to Section 9.26.3.4 of the National Building Code of Canada 1985 shall be placed on the warm side of the insulation before the interior finish is applied.

(24) A continuous granular drainage layer of crushed stone or gravel shall be installed under all wood footings and under floors of preserved wood foundations. This layer shall be at least 125 mm thick and shall extend at least 300 mm beyond the footing plate. The crushed stone or gravel shall contain no more than ten per cent of fine material passing a 4 mm sieve, and with no material larger than 40 mm. The granular drainage layer shall drain to a sump. Weeping tiles are not recommended around the perimeter of a preserved wood foundations.

(25) Backfill material against a preserved wood foundation shall be well-drained sand and gravel.

(26) Depending on the backfill height, additional blocking and framing anchors may be required in the floor system at the top of the foundation wall and around stairwell openings in the floor. Additional blocking and framing anchors shall be installed in compliance with Sections 3.10 and 3.11 of CSA Standard CAN3-S406 and the requirements for the amount and location shall be as specified by a licensed NASCOR manufacturer or a consulting engineer.

(27) An exterior moisture barrier shall be applied to the exterior sheathing. The moisture barrier shall consist of a 0.150 mm minimum thickness polyethylene sheet conforming to CGSB Standard 51-GP-51M.

(28) If brick veneer is to be used as an above grade exterior wall finish, a consulting engineer must make provisions for the extra load if it is to be supported by the NASCOR foundation wall.

(29) The foundation wall shall not be backfilled until the floors at the top and bottom of the wall are in place. All framing anchors and blocking should also be installed. The consulting engineer should inspect and certify the foundation wall before it is backfilled.

(30) The NASCOR I foundation wall shall be adequately protected during transit to prevent damage or displacement of the polystyrene insulation.

(31) The following Tables 5A and 5B specify maximum backfill heights.

Table 5A*

(Maximum Backfill Heights for NASCOR I PWF wall with Concrete Slab, Crawl Space, or Wood Sleeper Floors)

Vertical Load (kN/m)	Stud Spacing		
	300 mm	400 mm	600 mm
0 0	1.68 m	1.51 m	1.31 m
1.5	1.69 m	1.52 m	1.32 m
2.9	1.70 m	1.54 m	1.34 m
4.4	1.71 m	1.55 m	1.36 m
5.8	1.72 m	1.56 m	1.38 m
7.3	1.73 m	1.57 m	1.40 m
14.6	1.80 m	1.64 m	1.47 m
21.9	1.85 m	1.70 m	1.54 m
29.2	1.90 m	1.76 m	-
36.5	1.95 m	1.82 m	-
43.8	2.00 m	-	-

Notes:

(1) Lumber = S.P.F. Grade #2 or better
(2) Stud Size = 38 mm x 140 mm
(3) Plywood = 15.5 mm thick

Table 5B*

(Maximum Backfill Heights for NASCOR I PWF Walls with Suspended Wood Floors)

Vertical Load (kN/m)	Stud Spacing		
	300 mm	400 mm	600 mm
0 0	2.28 m	2.12 m	1.92 m
1.5	2.30 m	2.13 m	1.93 m
2.9	2.31 m	2.15 m	1.95 m
4.4	2.32 m	2.16 m	1.97 m
5.8	2.34 m	2.17 m	1.99 m
7.3	2.35 m	2.18 m	2.01 m
14.6	2.41 m	2.25 m	2.08 m
21.9	2.46 m	2.31 m	2.15 m
29.2	2.51 m	2.37 m	-
36.5	2.56 m	2.42 m	-
43.8	2.61 m	-	-

Design Notes and Assumptions:

(1) Soil bearing capacity: 75 kN/m^2 or more.

(2) Lateral load from soil pressure is equivalent to a fluid pressure of 4.7 kN/m^2 per metre of depth.

(3) Deflection limit: L/300.

(4) Maximum unsupported foundation wall height is 2.44 m for a concrete slab basement floor.

(5) Clear spans for floors: 4.0 m or less.

(6) Maximum building width of 10.0 m.

(7) The exterior plywood must be installed with its face grain perpendicular to the studs.

(8) When columns are spaced 610 mm on center the plywood must be a minimum of 15.5 mm thick.

(9) Plywood with a thickness of 12.5 mm may only be used up to a backfill height of 2.06 mm.

6.0 ASSESSMENT

6.1 Compliance to Building Codes and Standards

The NASCOR I preserved wood foundation wall system complies with the requirements of the following building codes and standards:

(1) National Building Code of Canada 1985, Subsections 4.2.3, 4.3.1 and 9.15.1;
(2) CAN3-086-M84, "Engineering Design in Wood (Working Stress Design);
(3) CAN3-086.1-M84, "Engineering Design in Wood (Limit States Design);
(4) CSA Standard CAN3-S406-M83, "Construction of Preserved Wood Foundations";
(5) CSA Standard 080.15, "Preservative Treatment of Wood for Building Foundation Systems, Basements, and Crawl Spaces by Pressure Process"; and
(6) CGSB Standard 51-GP-20M (1978), "Thermal Insulation, Expanded Polystyrene".

6.2 Performance

Testing was done at the expense of the proponent by Warnock Hersey Professional Services Ltd. of Coquitlam, British Columbia. The test results and analysis are produced in Report No. 2/86 dated 29 September 1986 and entitled "Report of Combined Axial and Transverse Load Test on Cano Structures Inc. NASCOR Preserved Wood Foundation Wall System". The tables for the backfill heights were revised by a letter dated 27 May 1987 from Warnock Hersey Professional Services Ltd. to Cano Structures Inc.

6.3 Longevity

The preservative treated 38 x 140 mm wood studs are warranted against rot and decay for a period of 75 years by Timber Specialities Ltd., the producer of the treated wood studs.

7.0 INSTALLATION

7.1 The NASCOR I Preserved Wood Foundation Wall System must be installed in accordance with a licensed manufacturer's instructions which are summarized below.

(1) Layout the panels around the building perimeter in the correct sequential order.

(2) Insert splines in keyways to create air locks between components.

(3) Join the panels together by interlocking the splines with keyways in the adjacent panels.

(4) Tilt up the assembled wall sections and either toe nail the bottom plate to the foundation wall footing plate or if the footing is a concrete strip footing, set the wall on top of it.

(5) Brace the wall temporarily.

(6) Fasten a cap plate to top plate of the wall avoiding overlapping of joints within the same stud space.

(7) Install the exterior plywood sheathing taking care to embed all edges of the plywood sheets in an ample bead of caulking. The plywood is usually supplied by the customer.

(8) Install the basement floor and the floor at the top of the foundation wall with all necessary blocking and framing anchors.

(9) Install the moisture barrier on the exterior sheathing.

(10) Backfill the wall after having the construction inspected and certified by a qualified engineer.

7.2 Site Conditions

A layer of free-draining crushed stone or gravel at least 125 mm thick is installed under all wood footings and under floors of preserved wood foundations.

The site is excavated in such a manner that it drains toward the sump location (near the center of the gravel bed) and the drainage layer is placed so that it drains toward the sump as well.

The drainage layer must consist of a material of which no more than 10% will pass a 4 mm sieve and no particles are to be greater than 40 mm in size.

The minimum bearing value of the soil beneath the wall footings is to be 75 kPa. Unusual site conditions are to be reported to an engineer before the drainage layer is placed.

Subject to engineering approval and local building codes, a concrete footing may be used in place of a wood footing.

The lateral load from the soil pressure on the foundation wall must not be greater than 4.7 kN/m^2 per metre of depth.

The gravel beneath the footings is to be compacted in minimum 150 mm layers and shall extend 300 mm on either side of the footing.

No drainage layer is required for unexcavated crawl spaces where the final grade on the interior side of the foundation wall is the same height or higher than the finished grade on the exterior side.

7.3 Alternate Footing Details

(1) Wood Footing Plate

The NASCOR I foundation wall system can be placed directly over a wood footing plate. The footing plate is placed on top of the granular drainage layer and consists of a single 38 x 235 mm preservative treated wood member. The wall is attached to the footing plate by toe nailing through the bottom plate of the wall.

Joints in the bottom wall plate must be a minimum of 600 mm offset from the joints in the footing plate. See Figure 7.3.1 for a typical wood footing detail.

(2) Concrete Footing - Option A and B

Concrete strip footings are quite often used to support a foundation wall. They must be designed in accordance with allowable soil bearing capacity and local building code regulations. The bottom wall plate is not required to be attached to the concrete footing but is sometimes done to prevent movement during construction.

Figure 7.3.2 (a) shows Option A with the foundation wall attached to the concrete footing with a steel angle and the bottom wall plate sitting directly on the concrete. Figure 7.3.2 (b) shows Option B with the foundation wall attached to a wood member embedded in the top of the concrete footing.

7.4 Wall Fabrication

The NASCOR I foundation wall system is erected on site and then the plywood sheathing is attached. The plywood is generally 15.5 mm thick and is preservative treated. Depending upon loading conditions, 12.5 mm or 18.5 mm thick plywood can be used. The plywood sheathing is nailed to the studs with its face grain perpendicular to the studs. To maintain a proper moisture barrier, the joints between the sheathing panels are sealed by embedding the edges of the panels in a butyl caulking. All fastenings and nails shall be stainless steel.

Foundation wall studs cannot be drilled or notched for mechanical or electrical installations.

The cap plate, top plate and the horizontal members of rough openings are not required to be preservative treated as long as they are a minimum of 200 mm clear of the finished grade.

The plywood joints below grade are not required to be braced by blocking. Treated lumber cannot be cut lengthwise or notched and cross cutting should be avoided. When cuts are unavoidable, the cut surfaces must be treated by at least two applications of copper naphthenate preservative solution (recommended by the treated lumber supplier).

7.5 Corner Details

Shown in the attached figures are the typical methods of constructing the NASCOR I foundation wall corners. Figure 7.5 (a) is a 90° corner. Figure 7.5 (b) is a 45° corner. Angles varying from 45° to 90° would be accomplished in a very similar fashion.

7.6 Support Required for Foundation Walls at First Floor Level

(1) Support for Side Walls

The side wall is the wall to which the floor joists are running perpendicular. Galvanized metal framing straps are necessary to attach the floor joists to the foundation wall. When the height of backfill is greater than 1500 mm, every second joist requires a framing strap. When the height of backfill is less than 1500 mm, framing straps are required every 1200 mm on center. Minimum size of framing straps are 38 x 400 mm x 20 gauge. Figure 7.6.1 shows two similar methods of metal strapping. Framing straps are also required when Wood I's or floor trusses are used as floor joists. Framing straps should be attached to the floor header joist with three 76 mm nails and to the inner face of the wall with four 76 mm nails (i.e. 2 nails into the top plates and 2 nails through the interior nailer strip into the stud behind).

(2) Support for End Walls

The end wall is the wall to which the floor joists are running parallel. Full depth blocking is required between the header joist and the first floor joist away from the wall in line with the foundation wall studs.

When the height of backfill is greater than 1500 mm the first floor joist away from the wall is required to be reinforced with an additional minimum size member of 38 x 89 mm. The subflooring is also nailed to the reinforcing joist with 51 mm nails at 100 mm on center. Framing straps on the full-depth blocking are necessary and are installed at every second stud location for backfill heights less than 1500 mm. When the height of backfill is greater than 1500 mm, a framing strap is required at every stud location. See Figure 7.6.2 (a) and (b) for details on the above.

(3) Framing Support Around Stairwell Openings

Stairwell openings within 1200 mm of a side wall and/or within 1800 mm of an end wall require special framing and increased nailing to provide lateral resistance from backfill loads at the top of the foundation wall. Additional horizontal members are required as per Figures 7.6.3 (a) and 7.6.3 (b) and Table 7.6.3 (c) attached.

7.7 Backfilling

The basement floor and first floor (at top of foundation wall) must both be in place before backfilling commences. Temporary bracing can be provided if it is necessary to backfill before the floors are installed but it must be designed to withstand the lateral loads. Also, if a concrete footing is used, the foundation wall can be backfilled to mid-height before the basement floor is placed provided the wall is braced at a minimum 1800 mm on centre along the bottom of the wall.

Backfilling should be done in maximum lifts of 200 mm and proceed around the building uniformly so as not to cause wall deflection or racking. Large pieces of earth, rock, or frozen soil should not be used as backfill. Machinery used in the backfill operation should be operated perpendicular to the wall, not parallel to it.

The choice of backfill material to be used should be based on the properties of the native soil. If the native soil is of a free draining type (i.e. river gravel, coarse sand and rock mixture, sand) then it can be used as backfill. If the native soil has a poor porosity (such as clay, clayey silt, etc.) then the backfill should consist of a granular material such as gravel, sand, or pit run. The top 300 mm of backfill should be as porous as the surrounding native soil.

The finished grade should slope away from the building at a minimum slope of one in twelve (1 in 12).

Preserved wood foundations should not be installed below the water table of the surrounding soil unless a Professional Engineer has done an analysis of the conditions and made provisions in the design for these conditions.

The footings of preserved wood foundations should be placed below the depth of anticipated frost penetration.

7.8 Fastener and Nailing Requirements

The table below lists the nailing and metal fastening requirements for the NASCOR I foundation wall. It is based on the table for nailing requirements in the CSA Standard CAN3-S406-M83. Various modifications to the table have been made to reflect the NASCOR foundation wall manufacturing and erection operations. All nails and screws are to be stainless steel except for floor attachment and floor blocking.

Fastening Requirments

Construction Detail		Min. Length Fastener	Min. # or Max. Spacing of Fasteners
Foundation Wall Framing	Bottom wall plate to wood footing plate.	76	300 mm centers
	Bottom wall plate to 38 x 140 mm wall stud (end screwed).	76	3 each stud
	Top wall plate to stud (end screwed):		
	- 38 x 140 mm stud	76	3 each stud
	- 38 x 184 mm stud	76	4 each stud
	Plate to plate nailing for doubled top plates:		
	- 38 x 140 mm stud	76	2 each stud space
	- 38 x 184 mm stud	76	3 each stud space
Floor Framing (Nails)	End wall blocking frames to floor joists.	76	400 mm centers
	Full depth end wall blocking to floor joists (end nail).	76	2
	Sleeper floors - floor joist to wood footing and to sleepers (toe nail)	76	2 per joist

Construction Detail		Min. Length Fastener	Min. # or Max. Spacing of Fasteners
Floor Framing (Nails) (Cont'd)	Suspended floors - floor joist to ledger and top plate of interior bearing support (toe nail).	76	2 per joist
	Ledger strip to wall stud.	89	3 each stud
Floor Attachment to Foundation Wall	Floor joist and blocking at top of foundation wall to top wall plate (toe nail):		
	-38 x 140 mm wall plate	89	3 per joist
	-38 x 184 mm wall plate	89	4 per joist
	In addition, framing straps are required where backfill height exceeds 1500 mm.	76	Every 2nd joist
	Backfill less than 1500 mm.	76	1200 mm centers
Wall Sheathing and Subfloor	Sheathing to wall framing and subfloor to floor joists: - Nails:	51	150 mm centers along edges and 300 mm centers along intermediate supports.

Construction Detail		Min. Length Fastener	Min. # or Max. Spacing of Fasteners
Wall Sheathing and Subfloor (Cont'd)	- Staples	51	100 mm centers along edges and 200 mm centers along intermediate supports.

8.0 IDENTIFICATION

Each NASCOR I Preserved Wood Foundation Wall System shall be identified by the following:

(1) The manufacturer's name and phone number shall be painted on the exterior approximately every 5.0 m along the length of the wall.

(2) Each polystyrene panel shall have the phrase below stamped on the interior at least once:

NASCOR I SYSTEM$_{TM}$

BY

CANO STRUCTURES INC.

"A BETTER WAY TO BUILD"

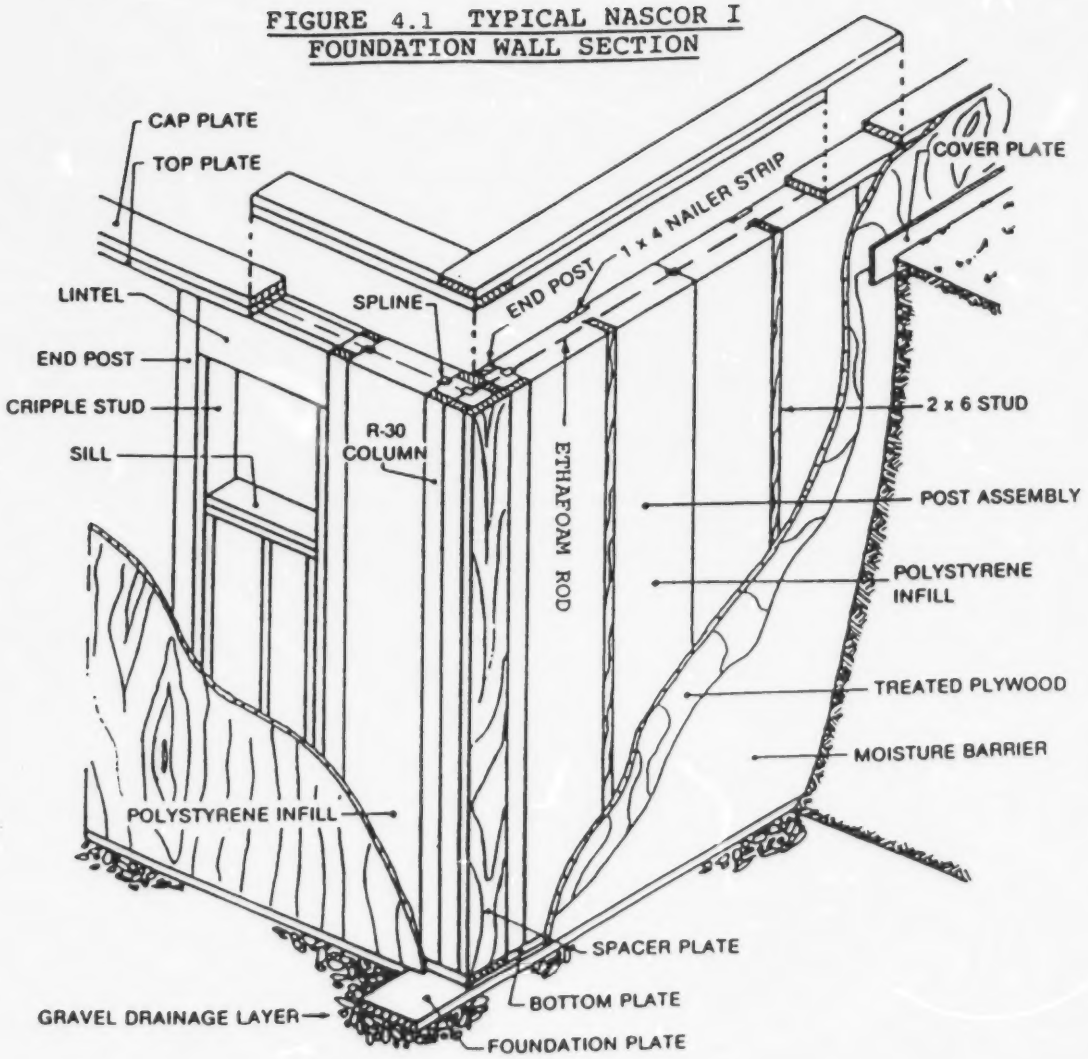
(3) The phrase **"See CMHC Evalaution Report No. 11608"** shall be stamped on the interior of each polystyrene panel.

NOTES

Readers are advised to confirm that this report has not been withdrawn or superseded by a later issue by contacting the Materials Evaluation Department at (613) 748-2280 or any CMHC local office.

Readers are asked to refer to limitations imposed by CMHC on the interpretation and use of this report. These limitations are included in the introduction to the "Manual of Building Materials Evaluation Reports" of which this report is part.

FIGURE 4.1 TYPICAL NASCOR I
FOUNDATION WALL SECTION



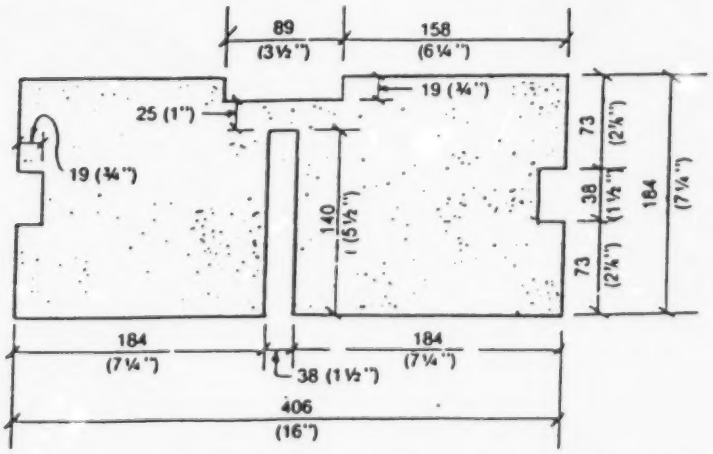


FIGURE 4.1.1 - NASCOR I PWF WALL INFILL PANEL

FIGURE 4.1.2 NASCOR I PWF COLUMN

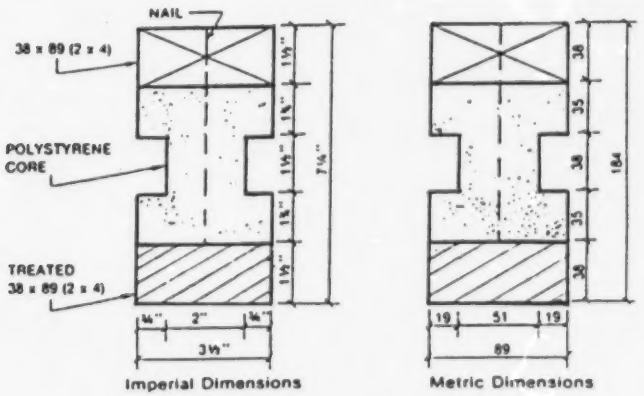


FIGURE 4.1.3 - NASCOR I PWF END POST

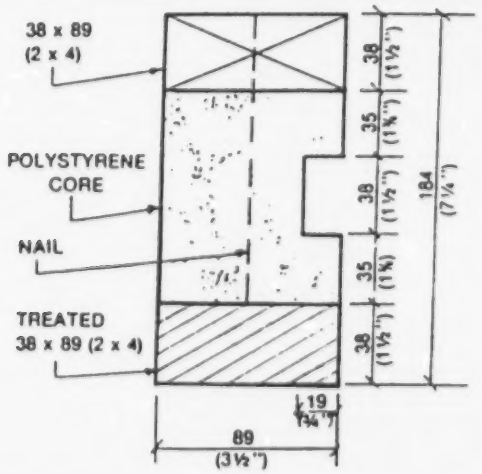


FIGURE 4.1.4 (a) TYPICAL FOUNDATION WALL LINTEL

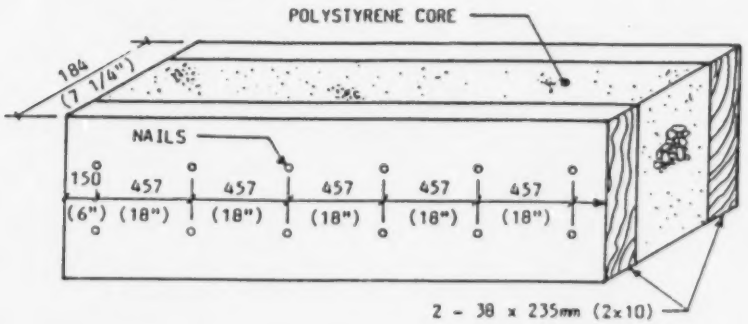
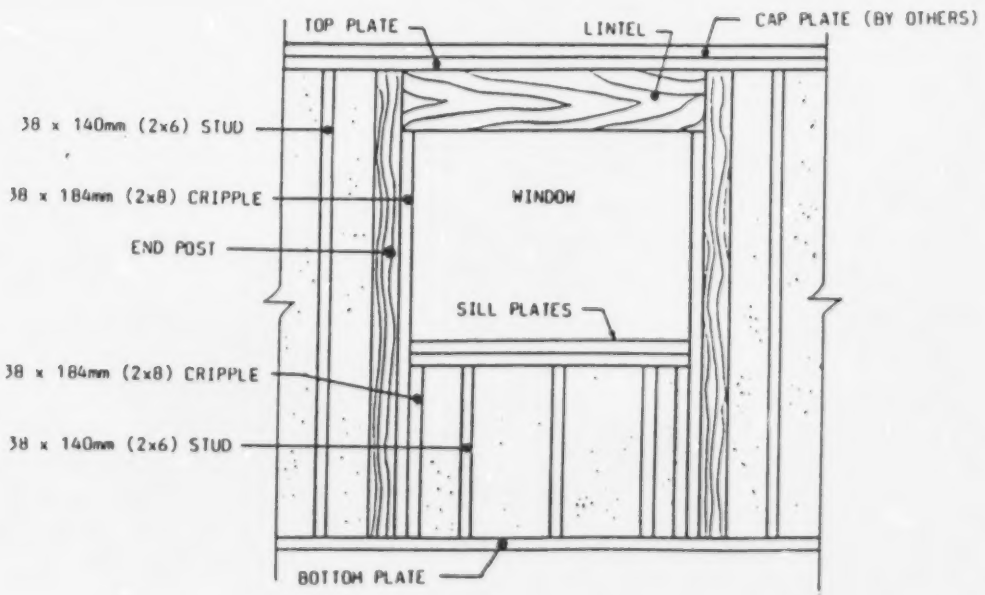


FIGURE 4.1.4 (b) EXTERIOR ELEVATION - ROUGH OPENING



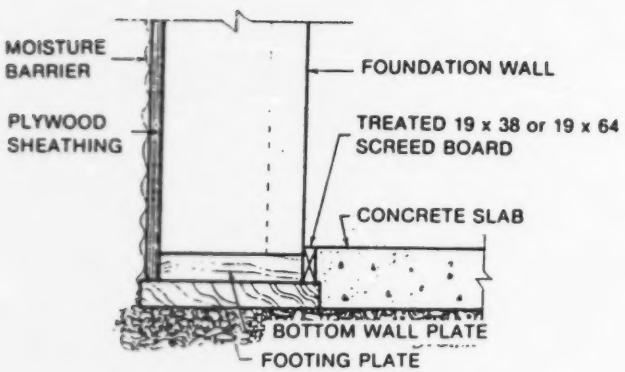


FIGURE 7.3.1 WOOD FOOTING

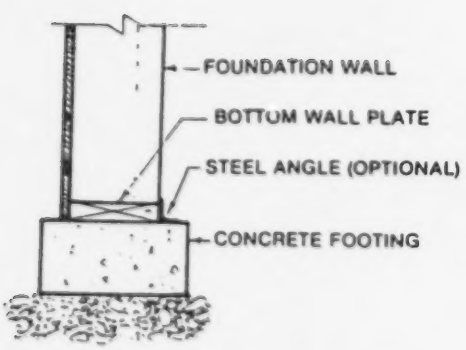


FIGURE 7.3.2. (a)

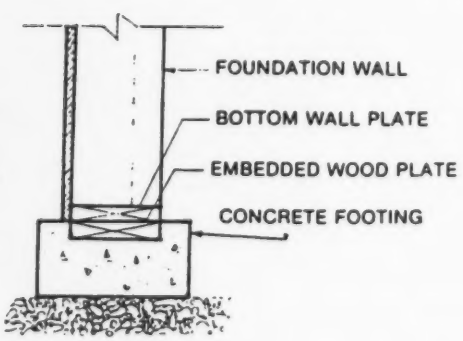


FIGURE 7.3.2 (b)

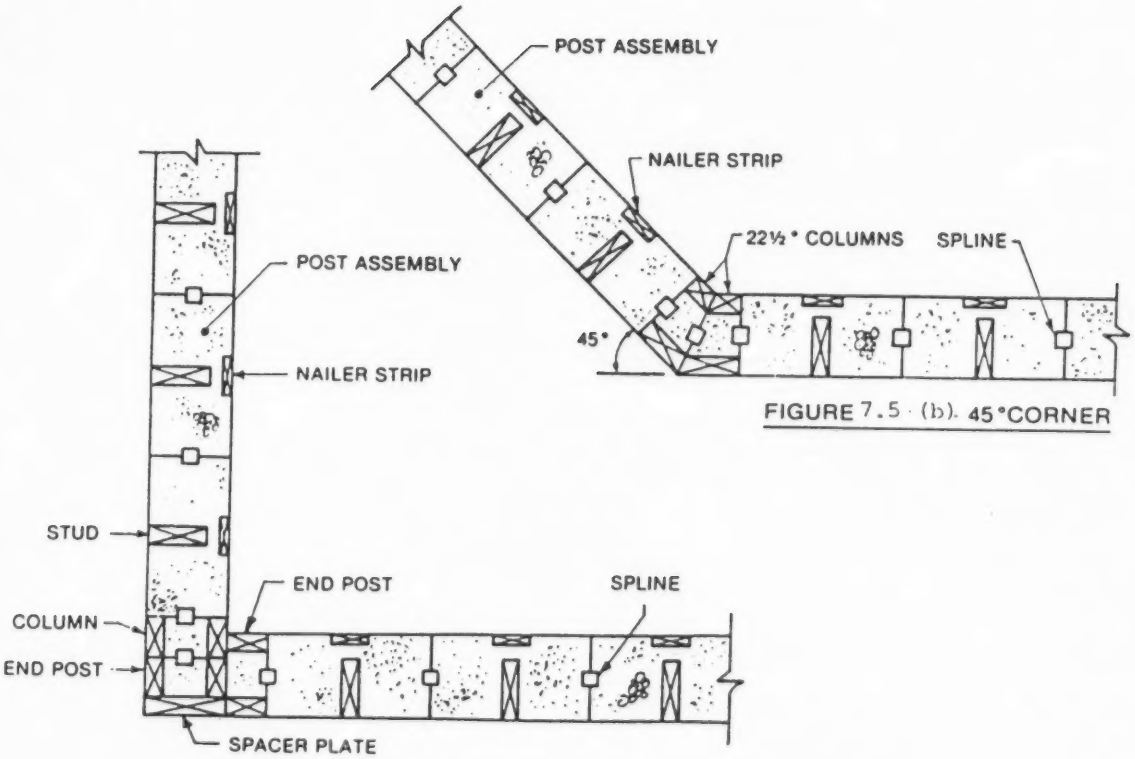


FIGURE 7.5 (b). 45°CORNER

FIGURE 7.5 (a) 90° CORNER

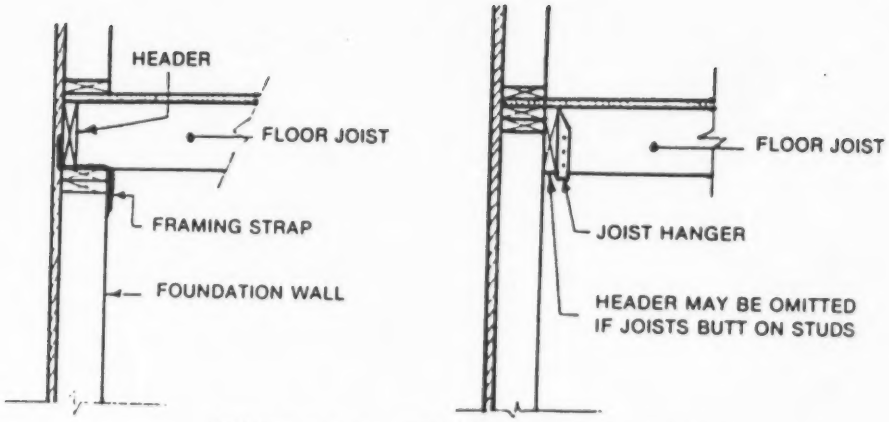


FIGURE 7.6.1 - FRAMING STRAP SUPPORT

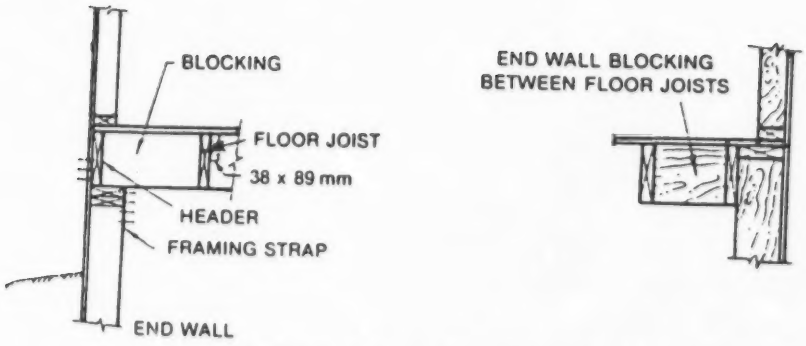


FIGURE 7.6.2 (a) - END WALL BLOCKING

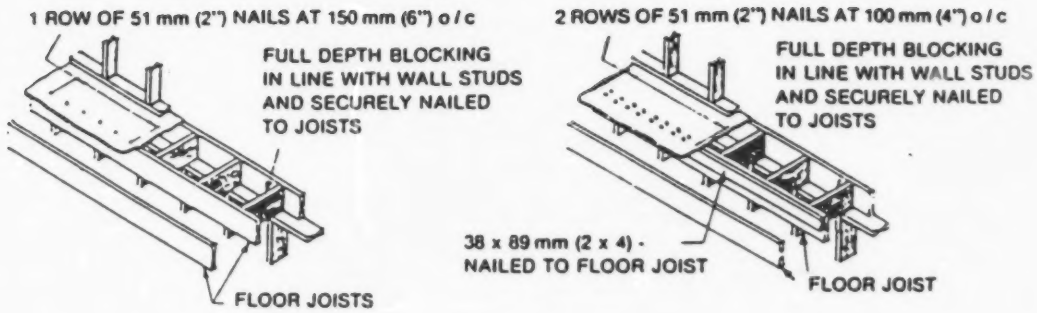

1 ROW OF 51 mm (2") NAILS AT 150 mm (6") o / c
FULL DEPTH BLOCKING IN LINE WITH WALL STUDS AND SECURELY NAILED TO JOISTS
FLOOR JOISTS
2 ROWS OF 51 mm (2") NAILS AT 100 mm (4") o / c
FULL DEPTH BLOCKING IN LINE WITH WALL STUDS AND SECURELY NAILED TO JOISTS
38 x 89 mm (2 x 4) - NAILED TO FLOOR JOIST
FLOOR JOIST
HEIGHT OF BACKFILL 1.5 m OR LESS
HEIGHT OF BACKFILL GREATER THAN 1.5 m

FIGURE 7.6.2(b)- END WALL NAILING

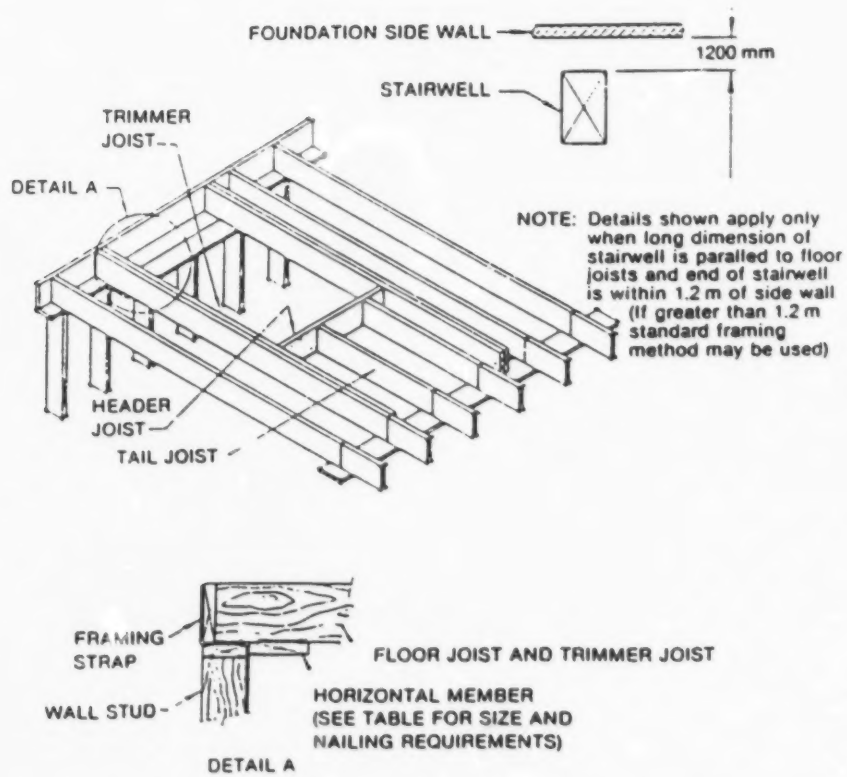
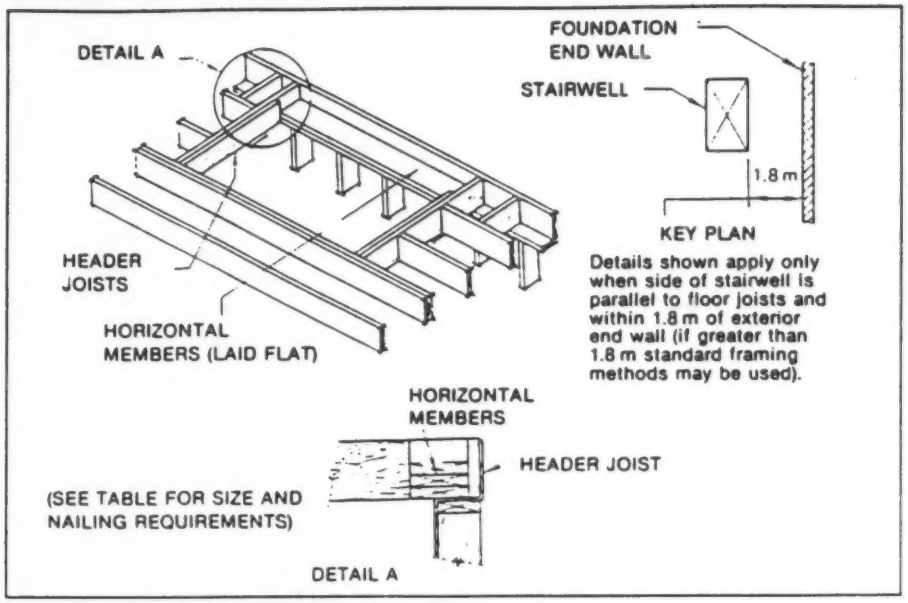

FOUNDATION SIDE WALL
1200 mm
STAIRWELL
TRIMMER JOIST
DETAIL A
NOTE: Details shown apply only when long dimension of stairwell is paralled to floor joists and end of stairwell is within 1.2 m of side wall (If greater than 1.2 m standard framing method may be used)
HEADER JOIST
TAIL JOIST
FRAMING STRAP
WALL STUD
FLOOR JOIST AND TRIMMER JOIST
HORIZONTAL MEMBER (SEE TABLE FOR SIZE AND NAILING REQUIREMENTS)
DETAIL A

FIGURE 7.6.3(a) STAIRWELL WITHIN 1.2 m OF SIDE WALL

FIGURE 7.6.3(b)

STAIRWELL FRAMING WITHIN 1.8 m OF END WALL


DETAIL A
FOUNDATION END WALL
STAIRWELL
1.8 m
KEY PLAN
Details shown apply only when side of stairwell is parallel to floor joists and within 1.8 m of exterior end wall (if greater than 1.8 m standard framing methods may be used).
HEADER JOISTS
HORIZONTAL MEMBERS (LAID FLAT)
HORIZONTAL MEMBERS
HEADER JOIST
(SEE TABLE FOR SIZE AND NAILING REQUIREMENTS)
DETAIL A

HORIZONTAL MEMBER SIZES AND NAILING REQUIREMENTS - STAIRWELL FRAMING

Basement Floor System	Height of Backfill, m	Location of Stairwell				
		Within 1.2 m of Side Wall		Within 1.8 m of End Wall		
		Horizontal Member Sizes, mm	Number of 76 mm Nails at Each End	Horizontal Member Sizes, mm	Spacing of Double Row of 76 mm Nails to Fasten Together Header Joists, mm o/c	Spacing of Double Row of 51 mm Nails to Fasten Subfloor to Header Joists, mm o/c
Concrete Slab or Wood Sleeper Floor	1.5 and Less	1 - 38 x 89	4	2 - 38 x 184	150	150
	Greater than 1.5	1 - 38 x 184	7	3 - 38 x 235	50	50
Suspended Wood Floor	2.0 and Less	1 - 38 x 89	4	2 - 38 x 184	150	150
	Greater than 2.0	1 - 38 x 184	7	3 - 38 x 235	50	50

NOTE: Horizontal member sizes are based on a maximum clear span of 1.2 m for end of stairwell and 3.2 m for side of stairwell.

TABLE 7.6.3(c)